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"LOOKING BACKWARD."

THE present number of the ELECTRICAL REVIEW marks the close of the twenty-fifth year of this Journal's existence. From November 15th, 1872, down to the present day, the continuity of issue has been unbroken, and 1,042 separate numbers have been published. Those having a taste for figures may be interested to learn that these numbers are made up of 25,754 pages of letterpress and nearly 15,000 illustrations. The Journal was started on November 15th, 1872, as the TELEGRAPHIC JOURNAL AND MONTHLY ILLUSTRATED REVIEW OF ELECTRICAL SCIENCE; two months later the sub-title of ELECTRICAL REVIEW was added. Six months only had elapsed when the publication was issued fortnightly, and it continued in that form until January 7th, 1882, when a weekly series was commenced, which has been continued uninterruptedly. Twenty-five years is a long period in electrical science—it embraces the fruition of industrial telephony, and the commercial development of the dynamo. When this Journal was first established, the dynamo machine was practically unknown outside the walls of the laboratory; which is equivalent to saying that beyond telegraphy and electro-plating, there were few signs of that great electrical revolution that has since wrought so marked an effect upon the social and industrial life of the world.

The commercial development of electricity was obscured in futurity, and the marvellous success that had attended telegraphic enterprise did not suggest that we were on the eve of a great industrial development. In a general way one speaks lightly of the progress made during the past quarter of a century; but when one considers with a sense of detail all that has been accomplished in that period—a short space in the history of social and scientific evolution—and ponders upon the achievements of the present generation, and the position occupied by the pioneers of electrical science, one is amazed. It has been veritably a triumphal progress. Alexander and Julius Cæsar never conquered new lands with the rapidity that has marked the advance into the domain of electrical invention. There has been no halting; one position after another has yielded to the unceasing pertinacity of a well drilled army of scientific investigators, and whatever may be the achievements of the future, it is certain that at the present moment we have much to look back upon. There is a probable reason for the extraordinary rapidity with which electrical science has advanced. For the most part, the men who have engaged in electrical work, and we are now speaking of the present generation, have been trained with a care and precision that scarcely finds a parallel in any other profession or industry; but it must never be forgotten that before they commenced their operations the land had been carefully spied out. The pioneers of electrical science were like Joshua and Caleb, who knew the possibilities that awaited the entrance of the faithful into the promised land.

Since 1872 a period of incessant activity has prevailed. Event and invention have followed and tumbled over each other in such confusion, that there has been a danger of overlooking the merits of individual inventions. At different periods we have undoubtedly suffered from a plethora of electrical invention, and many were the men of genius who in the early days failed to achieve instantaneous success because the results of their labour were in advance of the requirements of the time. The fruits of electrical invention were ripe before the world was ready to receive them.

No better comparison could be made between the subjects now engrossing the attention of the electrical profession and those upon which the electrical world was engaged when this journal first came into existence, than by comparing the range of articles in the present issue with those of November 12th, 1872. In the first issue we find "An Application of Magneto-Electricity," by Sir Charles Wheatstone; Sir James Anderson's "Account of Marine Cables Laid;" "On a Voltaic Standard of Electromotive Force," by Latimer Clark, while

the subjects that call for special treatment in this present issue, each representing an important branch of the electrical industry, number 23, and yet more might have been added.

On an occasion like the present we may be permitted to reflect with some satisfaction upon the position we ourselves have attained in electrical engineering. At the time when this Journal commenced to represent the interests of electricians, the Society of Telegraph Engineers had been in existence only a few months; since that time we have shared in the adversity that has occasionally swept over the electrical industry. There were many gleams of the silver lining, even in the early days; then, after '88, came the dark days of disaster, when the growing electrical industry seemed to be hopelessly crushed. The vitality, however, was only temporarily suspended, and when the trail of the ruthless speculator was effaced, there soon followed a healthy revival, and the strength of electrical invention gradually asserted itself.

Without putting our claims too high, we may fairly say that we have done something to foster the growth and development of legitimate electrical undertakings, both in their scientific and commercial aspect.

There is no branch of electrical science that has not received full and adequate treatment in these columns; and if this statement needed any corroboration we could refer with pardonable pride to the past volumes, which form a remarkable collection of valuable information. We have ever extended a hearty welcome to new discoveries, and have always paid the highest tribute to genuine scientific investigation, but we have always endeavoured to set forth the true value of discovery and investigation.

Honest invention has ever commanded our deepest sympathy, and we always endeavoured to uphold sound enterprise. We have no doubt been often blamed for the rigour of our criticisms, but the perpetual motion man, both of the scientific and financial type, has been a constantly recurring incident in electrical enterprise, and strong treatment was necessary to keep him in partial subjection. But if at times we have been led to take what appeared harsh, and, to those directly concerned, unreasonable views, we have never arrived at any opinion by reason of undue influence, and what we have said has been, according to our views, in the best interests of the electrical profession.

If any justification of our methods were needed, it is only necessary to say that since 1856 the nominal capital of companies formed to carry on electrical processes has aggregated £178,000,000 and probably two-thirds of these companies have gone clean out of existence. We have sought to keep the electrical industry clean, and we venture to think that we have achieved some success. In the first number of the Electrical Review it was announced that "the independence of the Journal will be secured by not seeking aid from departmental or other collective authority; the only authority tolerated in these pages will be born of right and reason." We have endeavoured to maintain the foregoing precept, and whatever success has been achieved in the conduct of this Journal, has been secured without adventitious aid; we have not been dependent in the remotest degree upon any cult, upon any sect, and when we say that, we are not forgetting how much we owe to the kindliness of friends whose assistance sprang from disinterested motives of friendship.

We could not allow the present occasion to pass without expressing our gratitude to those gentlemen who have helped us to mark the present period of our existence by giving an account of the progress made in that department of science in which they are mostly concerned.

TWENTY-FIVE YEARS' PROGRESS IN INCANDESCENT LIGHTING.

By J. W. SWAN, F.R.S.

Progress in incandescent lighting can hardly be said to extend so far back as the date of the establishment of the *Electrical Review*. At that time, if any progress had been made, it was of an extremely slow and halting kind, and several years had to pass before the point was reached when incandescent lighting began to make headway.

In 1872, though many abortive attempts had been made to realise the idea—not only was there then no practical incandescent lamp, but there was no expectation or faith among scientific men in the probability of such a thing being produced.

It was a time of great activity in matters electrical; much had been done, and much was being done in the way of approach from many converging directions on the point towards which we are looking.

An immense impulse had been given to inventions for the utilisation of electricity by the demonstration in a most practical form of the fact that motive power was a highly economical means of generating electric current. Gramme and Siemens, not to speak of others almost equally active in the same field, had each made their contribution towards the evolution of the dynamo; and inventive minds were being directed to its improvement, and busily at work on the means of its practical application. The development of light by means of the electric arc, was the thing chiefly aimed at. Great improvements were being made in arc lamps, and there was marked progress in the use of arc lighting.

But it was evident that however perfectly the arc lamp could be made to operate, there would still be a very wide field left vacant, which could only be filled by a smaller and milder illuminant, of which, an incandescent lamp was the ideal. The idea was by no means new, for Grove had propounded it in 1842, though not in a useful form. In 1845 Staite improved upon the elementary idea of Grove, and Starr, about the same time, went a good deal nearer a practical invention of the kind; he made a lamp having two of the characteristic features of the modern incandescent lamp—the light-giving body of his lamp being carbon, and the carbon in a vacuum.

These early experiments, and others of a similar kind bring us up to the year 1872, and they had not brought forth an efficient and practical incandescent lamp. The lamps with metallic conductors like Grove's, did not give sufficient light for the power expended, and the carbon lamps of the design of Starr were cumbrous, costly, and radically defective. And for the rest of the carbon lamps, acting on the principle of incandescence invented up to this time, the means used for the production and maintenance of the vacuous space in which the carbon was heated, were inadequate to meet the extremely exacting requirements of an economical and durable lamp.

The truth of the saying that "necessity is the mother of invention" is well illustrated by the circumstances and incidents which attended the evolution of the incandescent lamp; the want was so obvious and the necessity so urgent, as to strongly stimulate fresh effort to overcome the technical difficulties which alone stood in the way of its successful production. Happily, some of these were opportunely smoothed away by previous and concurrent invention, discovery and suggestion.

Sprengel had, in 1865, by the invention of his admirable mercury pump, put into the hands of physicists an improved means of obtaining high vacua, and Crookes, in connection with his radiometer research in 1877, showed how effective it was capable of being made, and in the radiometer bulb he accidentally suggested the bulb of the modern glow lamp.

The experimental work which had been actively carried on both here and in America since 1877, culminated in 1880 in the establishment of the incandescent

lamp manufacture on a commercial basis, and on the same general lines along which it has, up to the present time, been developed and extended all over the world.

The history of this development and extension coincides with the development and extension of electrical engineering, and with that of the great industrial use of electricity which is one of the striking features of the time, and is largely the outcome of the success of the incandescent lamp.

The technical progress in incandescent lighting since 1880 has been very great—the commercial progress has been even greater. Perfection was not reached in one stride, either in the design or workmanship of the incandescent lamp. Increased skill, the result of experience, led to general improvement, and as time went on, important structural changes were made, tending to the elimination of early defects. The connection between the carbon filament and the leading in wires was greatly improved by the electro-thermal deposition of carbon at the points of juncture, and the material out of which the filament itself was made, was much improved. It is now more uniform and in every way better than it was formerly, with the result that lamps of smaller candle-power for high voltage can be made, than was possible ten years ago: also the amount of light per watt has been materially increased. Whereas, at the outset, an efficiency of one candle for 3¾ to 4 watts was considered a fairly good performance, now it is practicable to obtain this amount of light with 25% less watts; of course it is only possible to take full advantage of the higher efficiency in the exceptional cases where the voltage is uniform.

Another direction in which there has been wonderful development, has been in the variety of the lamps. From the simple 8 and 16 candle-power lamps of the early days of the manufacture, the types have increased to many hundreds, with varying powers, from the tiny glow-worm spark of the microscopic surgical lamp to the monster of a thousand candles. What with fairy lamps, lamps for scientific and theatrical purposes, lamps for advertisement and for signalling, lamps bright and lamps frosted, lamps coloured and lamps clear, lamps of plain forms and lamps of fanciful forms—one is apt to be bewildered by the variety.

Another line of technical progress is in the durability and the keeping up of approximately the original efficiency. Modern lamps of the best make do not blacken as the primitive lamps did. I do not mean that there is absolutely nothing further to be desired in that respect, because it is still possible to darken even the best modern lamp by subjecting it to a voltage greatly in excess of that for which it was made. I mean that this fault has been much reduced, and even rendered trivial, and I believe that finality in this direction has not been reached.

Coming to the line of commercial progress, it will be remembered how utterly unprepared the world was in 1880, to take immediate advantage of incandescent lighting. The then existing dynamos were few, small, and inefficient; there were no central electric supply stations. The bold experiment in electric current supply from a central station, initiated by Mr. Edison, in New York, did not instantly demonstrate that incandescent lighting was capable of being turned to profit. The results had to be waited for, and other experiments of the same kind as that at New York had to be tried before the commercial soundness of electrical distribution from a central station became established, and no great progress was possible until this point had been reached. The time pending this was the most critical period in the history of electric lighting.

The Paris Electrical Exhibition of 1881 had given a strong impulse to commercial enterprise in connection with electrical undertakings. Public expectation as to the capabilities of electric lighting was at the highest pitch, and there was blind faith in the great possibilities of electrical achievements—a faith, that in the long run has happily been largely justified by the event, but that was quite unreasonable in its excessive optimism and want of allowance for the time necessary for the provision of means to ends. Over sanguine and not always over scrupulous adventurers took advantage of this frenzy of innocent faith, and in attempting to realise the impossible—failed; much money was thrown away on useless or premature enterprises, and public confidence was rudely shaken. This check was unfortunately accentuated by unwise legislation, which, by placing the fruits of enterprise almost out of reach, well-nigh paralyzed it. But if in consequence of these drawbacks progress was slower, it was also surer. It gave opportunity for working out innumerable necessary details and improvements in the matter of the dynamo, cable laying, current distribution, and pressure regulation, and for the designing of suitable and appropriate lamp fittings, switches, cut-outs, voltmeters, ammeters, supply-recording meters and a host of other things; the ultimate result being that fewer and less serious mistakes have been made than would have been inevitable if the pace had been much faster.

Meanwhile, valuable tentative advance was being made through the lighting of steamers, theatres, detached residences, factories, and hotels.

The improvement made in the storage of electrical energy unquestionably gave material assistance to the introduction of electric lighting in the earlier stage of its progress. There was then prevalent a great dread of the failure of the current and the extinction of the lights; so much so, that often gas fittings were left in their old place, and were even made a part of new installations as a safeguard against this danger. The secondary battery met this. It did more, it steadied the pressure in the case of small installations driven by gas engines, and provided a supply of current after the engine had stopped.

Whilst the mechanical engineer was making common cause with the electrical engineer, and they were groping their way to those triumphant results which have since been arrived at by their united efforts, and whilst all the complicated problems of electric current distribution were in process of practical solution, the manufacture of the incandescent lamp has gone on in a continual and steady progress, both technical and commercial till now. There is no longer any question either as to the excellence or the economy of incandescent lighting, and none as to the public demand at a profitable rate for the supply of electric current; the progress latterly has become increasingly rapid, and a prospect is opened out of immense expansion. How far that expansion may extend it is impossible to forecast; but the imagination may be assisted by a computation made by one in close touch with the commercial side of the lamp industry, that, at the present moment, the number of lamps in use in different parts of the world expressed in the eight-candle power equivalent, is probably not less than 50,000,000.

TWENTY-FIVE YEARS OF DYNAMO-ELECTRIC MACHINERY.

By W. B. ESSON, M.Inst.C.E.

In 1872 the dynamo of Gramme took practical shape, thus it happens that the Electrical Review, in celebrating its jubilee, celebrates at the same time the twenty-fifth anniversary of the appearance of the machine which made possible electrical engineering as known to moderns. One of Gramme's dynamos was brought to London in 1873, and it certainly presented an appearance but little resembling that of its progeny. It was, more properly speaking, three dynamos combined in one, for it had three sets of magnets and three armatures mounted on one spindle. One of these armatures was employed to excite the magnets, while the two others supplied the current to the outside circuit.

Six years before Gramme obtained his first patent, Pacinotti had illustrated and described in the *Nuovo Cimento* the remarkable machine of his invention. This, no doubt, embodied in crude form all the elements of the Gramme machine. It had the closed coil winding of the armature; it had the iron ring core and the equivalent of

the present day commutator. Nevertheless, until Gramme brought his mechanical genius to bear upon it, this machine of Pacinotti's, prototype of numberless generators since, remained but a scientific toy.

Gramme had a strong bias towards multiple armatures, but still a stronger towards multiple magnets combined in a common pole. As the machines were required to give larger outputs magnets were added, and thus two or three sets lying parallel to each other were often seen in his machines. Those who visited the first Electrical Exhibition at the Crystal Palace will no doubt call to mind the collection of Gramme machines exhibited by the British Electric Light Company, in which figured conspicuously machines with double magnets. But Gramme was not the only designer who had this weakness. Later, both Weston and Edison arranged their magnets in parallel groups, under the impression, erroneous as we now know it to be, that the result was certain gain.

Bürgin did his best to spoil the Gramme machine, and succeeded to a remarkable extent. For Gramme's one simple ring of iron wire he substituted for the armature core eight hexagonal rings mounted on one spindle, each wound with six coils of many turns. The machine has long since gone to its final rest—on the scrap heap, but from a historical point of view it possesses no little interest as indicating how little was known in those days, of scientific designing. And with all its faults it did very good service indeed in its day.

Thin washers were at an early date substituted for iron wire to form the armature core, and early in the eighties Maxim appeared with a combination of the Gramme and Pacinotti machine, to wit, a Gramme wound armature having a core with grooves on the exterior, in which lay the wires. Fein thought he would improve Gramme's machine by carrying continuations of the poles inside the armature; while Heinrichs came along with an armature core of extraordinary section, and Gülcher thought he would mend matters by making the greater dimension of the armature lie perpendicular instead of parallel to the shaft. Needless to say these were all mere modifications, and bad at that, of one machine, and that one Gramme's. They have all disappeared, for the ring-wound dynamo of to-day, though vastly improved from a mechanical point of view, and greatly modified as to proportion, remains virtually the machine introduced by Gramme 25 years ago.

But the Review has still another twenty-fifth anniversary to celebrate, for just about the time that Gramme's machine made its appearance in France, the machine of Von Hefner Alteneck was made public in Germany. Everyone knows the so-called Siemens armature, and is aware that the numerous modifications of its particular winding which Alteneck invented, are now in use to a much greater extent than is the Gramme winding. In the machine of 1872 the armature coils, mounted on a light cylindrical shell of German silver, revolved round a fixed core; but this was soon abandoned in favour of coils wound direct on a core, which in turn was fixed on the shaft. Von Hefner Alteneck's winding was not symmetrical, and the coils were few in number. In no sense can it be said that the early examples of his machine were so good as those of Gramme. But very soon symmetrical methods of winding were introduced by Frölich and Breguet, while the coils were greatly increased in number, till they became comparable with the sections on Gramme's armature. It is well to remember that in the original winding of Alteneck, as well as in Frölich's and Breguet's modifications of it, the coils lay across a chord of the core circumference, and not across its diameter. With certain mechanical improvements the drum winding was in due course appropriated by Mr. Edison, and also adopted by Weston, who introduced with it, in the machine which bore his name, a slotted core.

From these historical notes the Brush machine must not be omitted. In the early eighties this machine gave an immense impetus to electric lighting, which was good for the industry, and an immense impetus to company promoting, which did it incomparable harm. From time to time the machine has been improved, but its design is virtually the same to-day as when it first appeared, and it is doubtful whether for arc lighting in series it has ever been beaten.

Alternating current machines were first used as constituting part of a distributing system for arc lighting, and in 1875 the prototype of the modern machine appeared in the generator of Lontin. This machine had a fixed armature, consisting of a series of coils wound on radial cores and a rotating field, which had a corresponding number of radial magnets. At the present time, the only alternator having an armature with clearly defined radial poles is the one made by Ganz & Co., which is to all intents a Lontin machine, with all up-to-date improvements. In 1878, Gramme invented an alternator for the purpose of feeding the circuits of Jablochkoff candles. This machine also had a fixed armature and rotating radial magnets, and incidentally it was the first polyphase machine. The coiling of the armature was similar to that of the ring in Gramme's direct current machine, but this form of armature for alternators has now disappeared. The last example seen by the writer was furnished by the large machine exhibited at the Frankfort exhibition by Siemens & Halske. The Siemens alternator—Wilde's 1867 machine without the armature cores, made its appearance in 1879, a year after Gramme's; this being typical of all the coreless alternators which have since been constructed.

It would be impossible, in brief space, to notice the many modifications of these typical machines, which have been introduced from time to time; but the lines upon which design has proceeded generally, are well defined, and may be briefly referred to. In the early days of dynamo designing the idea of the magnetic circuit had no existence. Electricians talked about magnetic moments and other things, which did not in the least apply to dynamos, gave their views with becoming modesty on the effect of idle wire on the armature, and invented with a zeal worthier of a better cause all sorts of impossible machines. But gradually the idea of the magnetic circuit, vague at first, began to assume shape, while Kapp's 1886 paper, and the Hopkinsons' classic contribution to the Royal Society in the same year, provided a rational foundation on which to build, and secured acceptance of the magnetic circuit idea as a fundamental principle of design. Before that, however, great improvements had been made. Dr. Hopkinson had taken the drum machine in hand, had done away with the long multiple magnets of Edison, substituting for them a heavy short magnet, having a much larger cross section of iron, and relatively much less wire on it. Mr. Crompton had taken in hand the Gramme type of machine, and had improved its design in similar manner by increasing the radial depth of the ring core, and greatly increasing the cross section of the magnets. In both types the weight of iron was made greater relatively to the weight of the copper, the magnetic circuit being shortened, and its area increased so as to get better results from a given magnetising force. This represents the main difference electrically between the earliest machines and the latest, and it is interesting to note that both the designers mentioned arrived at the same result, one led thereto by theoretical considerations, and the other, it is said, by engineering intuition.

Structurally the early designs were on the lines adopted by mechanicians and instrument makers. But soon it was realised that the dynamo being a power-transmitting machine, its manufacture should be in the hands of engineers. The flimsiness of the early forms, which were of comparatively small size, has long since disappeared, and to-day the dynamo is a solidly-constructed machine built on the best engineering lines, with all the parts properly proportioned for the large forces they have to transmit. Whereas 20 years ago a 50 H.P. dynamo was considered a marvel, in 1897 direct current railway generators giving 500 H.P. are quite common. The laminated armature core is, in such machines, securely bolted to a steel central hub, which in its turn is firmly keyed to a steel shaft running in heavy plummer blocks lubricated with

self-oiling rings. The armature conductors are positively driven by properly spaced driving keys on the periphery of the core, or, better still, are sunk right into the iron and thus shielded from the strains to which exterior conductors are subjected. The magnets are massive castings of steel, and the machines are directly coupled to the crank-shaft of a powerful steam engine.

In alternators the advance has been along the same lines; weighty fields and less copper in both fields and armature, and the careful elimination of parasitic currents. One has but to compare some of the early forms with the modern machines to mark the difference. In the former there was an air space measuring several inches, with consequent weak field, armature coils of many convolutions and excessive drop in E.M.F. as the load was increased. In the latter the gap is reduced to the fractional part of an inch, and the field is therefore of great strength, fewer turns are required in the armature coils, and there is consequently but a small E.M.F. drop as the load increases. These are the electrical differences, but the manufacture of alternators also passed long since into the hands of engineers, and structurally they resemble but in small degree their earlier forms. The coreless alternator with its armature coils, necessarily mounted in a manner at which an engineer rebels, has almost disappeared; now all the modern machines have their coils embedded in the armature core, either wound through holes or laid in slots. There are no conductors in the air gap, and practically no strains on the conductors. In 20 years we have gone in size from 5 to 5,000 H.P. It is a grand record of progress; from the machines which fed the Jablochkoff circuits for the lighting of the Avenue de l'Opera to the magnificent triumph of engineering realised in the generators of Niagara.

During the past decade giant strides have been made. Electric lighting taught engineers how to design machines but it is in power work, whether for traction or transmission, that the great future lies, and it is to this that they must look for the fruition of their labours. In power transmission a vast field lies ready for the tilling, and it is difficult to realise that 10 short years have seen the first application of polyphase currents, the birth and growth of the induction motor, and the daily transmission of 100,000 H.P. But so it is, notwithstanding that in this country engineers still appear to be ignorant of the advantages to be derived from the use of polyphase currents. These, however, have come to stay, and to the value of the induction motor indifference cannot be always shown. The department of polyphase machinery is daily becoming of more and more importance, and it is perfectly safe to predict that within the next 10 years the direct current motor will have given first place, even for workshop power transmission, to its more attractive rival.

TWENTY-FIVE YEARS' PROGRESS OF MILITARY TELEGRAPHY.

By R. von FISCHER-TREUENFELD.
Late Major commanding Paraguayan Military Telegraph Corps.

From the time of first introduction of electric telegraphy by Cook and Wheatstone, in 1837, to the era of the last 25 years, to which the progress of military telegraphy especially belongs, the reliability of and the confidence in electric communication as a means for rapid transmission of military intelligence had first to be established and recognised before systematic progress in military telegraphy could be expected. England produced the first practical electric telegraph, and the honour of introducing it into war is due to the British Army in the Crimea, when short lines were used at the siege of Sebastopol, 1854-55, connecting the camp with the harbour and headquarters; employing also for the first time a submarine cable as a military line.

Three years later, 1857-58, the English Army also carried for the first time telegraph material into the field during the Mutiny in India, using Wheatstone's needle apparatus and iron wires, which often for want of time, poles and insulators were laid on the ground, working well during dry weather. Those lines followed the advancing columns and connected Calcutta with the distant divisions and with Lord Clyde's headquarters. The excellent "impromptu" achievements during those campaigns were the starting point of field telegraphy, and they induced England, in 1857, to form a Military Telegraph School at Chatham, where non-commissioned officers and men of the Royal Engineers were trained in military telegraphy, so as to ensure their being of the greatest practical utility to a force serving in the field.

The next two large wars—the Civil War of the United States, 1861–65, and the Brazilian Paraguayan War, 1865–69—were of special interest to military telegraphy. In both struggles the telegraph service had to be organised with the *personnel* and *material* of the Civil Service; but owing to the duration of both wars, field telegraphy extended qualitatively over a sphere of action which never had been attained before, and was not even achieved in the 1870 war by either the French or the German Army. In the United States, as well as in Paraguay, telegraph stations had to be carried not only to the entrenchments of fortified places, but also to the advanced lines of moving divisions, thus proving the feasibility of the hitherto opposed hypothesis that electrical communication could be established advantageously to bodies of troops on the march, on reconnaissances, outpost service, or on the battlefield. The great opposition shown at that time in Europe to field telegraphy by commanders, as being prejudicial to their independent action, often seemed unsurmountable, and threatened to destroy all hope of progress. It was mostly due to an improper ambition and to a false conception of the strategical principle of modern warfare, *i.e.*, the union of extended action under a single will.

Thus stood field telegraphy in 1872, when the English Army Telegraph, consisting of the Chatham Telegraph School and the Aldershot Telegraph Troop, was considered by Captain (later General) Malcolm, R.E., director of the Chatham school, to divide itself into the following four classes. The *permanent*, of which the postal telegraph system was taken as a sample, and which was left entirely in the hands of the Post Office; the *semi-permanent*, or line connecting headquarters with the nearest permanent line. This was then already considerably used in India, but not yet fully arranged in England. The *field telegraph proper*, which connects headquarters with at least the divisional-generals, and, if possible, the various portions of the army. The telegraph troop, organised for this class at Aldershot, was, however, short of men and horses; and the *visual signalling system*, by which the various commanders are put *en rapport* by their own out-stations, posts, piquets, patrols, &c., and by means of which also communication from shore to ship may readily be maintained.

The Chatham Telegraph School, which the men of the Royal Engineers were always encouraged to volunteer for, was in 1872 divided into two classes. The lower class, occupying 49 to 77 working days, instructed the men in Morse-reading and sending by record and sound, testing, erecting lines, firing mines, and making up batteries; whereas the higher class, with 28 working days, taught the higher branches of testing cables, batteries, and fuses, and instructed the pupils in electromagnetism. Besides at Chatham, there was also, and is still, a telegraph school at Aldershot for the troops there.

The telegraph troop at Aldershot possessed in 1872 an establishment of four officers, 41 non-commissioned officers and men, mounted and dismounted, 16 artificers, 20 signallers, and 168 sappers, drivers and trumpeters; a total of 249 men. These were divided into three

sections, each carrying only 12 miles of a very heavy type of cable of 300 lbs. weight per mile; each waggon, drawn by six horses, carried three miles of cable, so that the whole telegraph troop only disposed of 36 miles of insulated wire. The cable waggons had a neat arrangement at the hindwheel, by means of which the cable, when laid out, can be rolled up, and which, slightly improved, has answered well till now, and made a great saving of labour. About three miles an hour could be laid out, whereas three-and-a-half to four miles of cable could be taken up per hour. The troop was also provided with office waggons of about 17 cwt. weight when empty, carrying the necessary stores and instruments to form a complete electric station, to be drawn by four horses, and weighing 26 cwt. when full, including telegraphers.

The synopsis of this early organisation showed two cardinal faults, viz., want of better means to obtain professional experience on the part of officers and men, and want of a much lighter and less voluminous station and line material, in order to increase the movableness of the equipment, and the length of the available line material; diminishing at the same time the cable waggons and horses. Both shortcomings were soon improved by a more adequate recruiting, by a more elaborate system of training, by the adoption of improved station and line material, and by a more suitable transport equipment. Colonel Hamilton, Colonel Jelf, Colonel Addison, Colonel Beresford, Major Bagnold, Major Hippisley, and the entire staff of officers at Aldershot and Chatham have restlessly worked to complete the innumerable details of waggons, arms, repairing accoutrements, camp equipment, harnesses and saddles, instruments, tools, ordnance, special—barrack—and miscellaneous stores, and military drill.

When the Government, in May, 1870, took over the telegraphs of private companies, the Royal Engineers detached some men of the 22nd and 34th Companies, under Captain (now Major-General) Webber, R.E., to effect the unification of those heterogeneous English and Scotch lines into one national postal telegraph. These men erected about one-third of the lines of the new system, to the greatest satisfaction of the State. Through Captain Webber's exertions, and with the object of procuring for the telegraph troop the best possible means of training, two officers and 21 non-commissioned officers and men were already in 1870 employed in postal telegraph construction and maintenance in the Eastern District. In 1871 the Eastern Engineering Division of Postal Telegraphs was formed, under Captain Webber, R.E.; in 1872 the district was increased, there were four officers and 61 non-commissioned officers and men. A detachment of these was sent under Lieutenant Jekyll, R.E., in 1873, to accompany the Ashantee Expedition, where they put up a line 110 miles in length.

The valuable arrangement of postal amalgamation with Royal Engineer troops, although at that time opposed by many voices from the Postal department, developed itself into the most important educational institution for Royal Engineer officers and men. This military establishment of the 2nd Division of the Telegraph Battalion was fixed in 1878 as a new organisation, taking charge of the telegraphs in the South and South-west of England, besides taking over the War Department telegraph lines at Chatham, Dover, Portsmouth, Plymouth, and Aldershot, standing under the direction of a Major R.E. and the Chief Engineer of the Post Office, and consisting of six officers and 165 non-commissioned officers and men, 60 being instrument clerks, and 105 for engineering and constructional purposes. These Royal Engineers were always ready to provide a sufficient number of trained officers and men for war purposes. The mileage of line wire in the Southern District, partly maintained and partly supervised by the Royal Engineers in 1886, was 26,516 miles, and the number of instruments 2,710, comprising quadruplex, repeaters, sounders, printers, bells, single and double needles, A.B.C.'s, telephones, exchanges, &c. Besides the ordinary telegraph duties, there is always a number of special events to be provided for, such as race meetings, political addresses, elections, cricket matches, rifle meetings, &c. There are two distinct classes of telegraphists, *i.e.*, constructors and operators, mostly obtained from the School of Military Engineering, or from the Telegraph School at Chatham.

The Telegraph Troop hence possessed three distinct institutions for learning, *i.e.*, the Chatham Telegraph School, the Postal Districts, and the Aldershot Field Telegraph Troop. By a proper interchange of services every man thus receives a most perfect training, so that the British Telegraph Corps is recognised to be one of the finest *troupe d'élite* in the world.

When the Zulu War broke out in 1879, Lord Chelmsford asked for a field telegraph, and this was the first campaign in which the Mounted Telegraph Troop went out, under Major Hamilton, R.E., and several lines were run out. The peace and war establishments of the old organisation of the Telegraph Troop at Aldershot, and the companies of Royal Engineers employed on postal telegraphs were, up to 1880, as follows:—Peace—208 officers and men in troop, and 160 officers and men in companies. War—304 officers and men in troop, and 261 officers and men in companies.

The experiences gathered during the Zulu campaign and otherwise were reported in June, 1880, in Colonel Harrison's Committee on Reorganisation of the Telegraph Troop and Companies, R.E., recommending that the Telegraph Troop and Companies should form for the future the "Royal Engineer Field Telegraph Corps," remaining distinct bodies in time of peace, but should be amalgamated for war service; that the war establishment should be increased from 304 to 440 non-commissioned officers and men, forming eight sections of field telegraphs, and that the mileage of telegraph to be carried be increased from 60 to 160 miles, exclusive of reserve units of stores; the corps being capable of taking the field at a week's notice. In war time the Telegraph Corps should be capable of sub-division into many small units, each complete in itself, and capable of working independently, to carry out the following duties:—Laying and removing telegraph lines with such rapidity as to keep the headquarters of a force in communication with its detached units; connecting the headquarters with the base of existing civil telegraphs, and taking possession of, and working the permanent civil telegraphs in the theatre of war. Each sectional unit made up to war strength to comprise 53 non-commissioned officers and men under a subaltern officer, carrying either 20 miles of cable, or 20 miles of overhead telegraph material. The maintenance of the whole of the Post Office Telegraph system in the Southern district of England, together with all the War Department and Admiralty lines in that area to be handed over to the corps in accordance to the recommendation to the Select Committee.

In 1881, a combined section, under this new organisation from the Postal Telegraph Royal Engineers' companies, and from C troop, Aldershot, was despatched to Natal under Lieutenant (now Major) Bagnold, R.E.; they laid a line to Pretoria, which proved of great value. It was, however, during the Egyptian campaign of 1882 that the new organisation and its excellent system of training fully came to light. On the arrival of Sir Arthur Mackworth, R.E., with the section, their first task was to repair the existing lines as quickly as possible, and then push on to the front. Here, for the first time, one officer and a small party of mounted telegraphers were attached to the cavalry division to accompany reconnaissances, and when on the 9th of September the enemy attacked from Tel-el-Kebir, the telegraph station worked under fire with coolness and precision. A cable line accompanied the advance on Tel-el-Kebir, to be followed up by an overhead wire. During the action which ensued, the telegraph was present throughout and under fire, and Lord Wolseley reported the victory from the battlefield to Her Majesty, and to the War Minister, and in 45 minutes the Queen's reply was received. The cable, with which this feat could be achieved, was Siemens's old Austrian pattern from 1879, and the instruments were Cardew's vibrating

sounders and telephone. The telegraph corps had thus verified its great military value, and had shown itself to be quite able to cope with the necessities of strategical telegraphy, as well as with the maintenance of communication between marching divisions and headquarters, following the rapid movements of cavalry, and working at the front during the supreme moments of the encounter of arms. This highest standard of efficiency has, in spite of climatical and many other difficulties, been kept up during all following campaigns, when according to requirements and occasions, every kind of telegraphic communication had to be established, thus confirming that no extended operations can now be carried out without the aid of the telegraph, and that its presence is as necessary to every part of an army as nerves are to a living body.

During the Nile expedition, 1884-85, in Bechuanaland, with Sir Gerald Graham's force to Suakim in 1885, as also during the later Ashantee and Nile campaigns, light overhead lines, as well as field cables were extensively used. Major Turner, Director of Telegraphs, and Lieutenant Lindsay, R.E., during the advance towards Tamai, established a telegraph station in a zareba, where the detachment had also to assist in the fighting, and at the hand-to-hand struggle of To Frik the dead enemy were lying within two or three yards of the telegraph instrument.

Field telegraphy in India is on a different footing; sappers and miners are largely supplemented by civilian State telegraph employés, whereas "Army-Signalling" is a purely military organisation. Before the Afghan war in 1879-80 the Indian Army had hardly taken any steps for the organisation of telegraphic communication in the field. The Director-General of Telegraphs, Colonel Murray, recognising this want, organised the first Indian Telegraph Corps with the *personnel* and *material* of State telegraphs, and under the command of Superintendents Luke, Pitman and Josephs it played an important part during that war. Since then an elaborate organisation, to suit the particular requirements of the country, has been worked out by the Deputy-Director of Telegraphs in India, Mr. P. V. Luke, C.B., wherewith, owing to the difficulties of mountainous regions, everything is arranged for "pack-animals." The frequent small expeditions across the frontiers of India and Burma have proved the excellent condition of the Indian field telegraph equipment, and it remains a feat, never attained elsewhere, to have erected a field telegraph during the Chitral campaign, on the Gilgit line, which crossed the Rajdiangan 11,600 feet high, and the Burzil 13,500 feet high, with snow in winter of 10 to 18 feet, so that the poles had to be 30 feet long, and to maintain communication with Gilgit almost uninterruptedly during the whole winter.

As the efficiency of the *personnel* of the Royal Engineer Field Telegraph Corps steadily advanced, so the perfecting of the *material* also kept pace. Up to 1872 the recording instrument was preferred, and Mr. W. H. Preece, C.B., already then recommended to depend entirely upon the Sounder for temporary but rapid military telegraphy. This created a lively controversy on Sounder *versus* Recorder, terminating with the adoption of the former, which proved the more accurate, lighter, simpler, and more portable apparatus. For stations with several main roads and numerous cross-communications, a suitable inter-communication system, or telephone exchange, has been adopted in several fortresses, dockyards, &c.; besides which a number of testing apparatus, batteries, Morse-recorders, sounders, galvanometers, switches, single and double current duplex circuits, automatic translators, telephones, and Wheatstone's A.B.C. instruments have been carefully arranged and remodelled by experienced officers of the corps, to suit the requirements of their various services.

Another controversy of paramount importance was that of Cable *versus* Air-line. With the heavy field cable adopted before 1881, requiring 12 waggons, with 72 horses for the transport of only 36 miles of line, movableness was largely impeded, and it became evident that the cable not only should be lighter, but that naked wire on poles, being less likely to be damaged, and more readily repaired, should also be provided with the equipment, and always be resorted to, where great speed of erection is not an object, and where a sufficiently permanent character of the field line is required; the cable only being considered suitable where communication is quickly required, but it should always be replaced as speedily as possible by air-line. A considerable step forwards was the adoption, in 1881, of Siemens Brothers & Co.'s field cable, as constructed for the Austrian army in 1879, its weight being only about half that of the old cable, whereas the breaking strain was nearly double. This made it possible to load each waggon with five instead of three miles, thus bringing the equipment to 60, instead of 36 miles of cable.

Another improvement which not only simplified the station apparatus, reduced its weight, abolished the old station waggons, but also enabled a further reduction in volume and weight of the field cable, was the invention of Captain Cardew's, R.E., vibratory-current system, the telephone being used as a receiving instrument for telegraphy. The great advantages of this vibrating apparatus for military work consists in the sensitiveness of the telephone, allowing the working with signals far inferior in power to those required to work even the most sensitive relay. It never requires adjustment, but will respond to the most powerful as well as the weakest signal; it can be super-imposed upon other systems, and the signals will, to a certain extent, pass through dielectric media. The system is, therefore, most suitable for cable lines, such as advanced military lines usually would be, and especially valuable where, owing to difficulties of transport or great haste in erection, the insulation is necessarily very defective. It thus became possible to reduce the insulating volume of field cables, and by increasing the tensile strength ot the conductor, so that the cable possesses great strength consistently with lightness and small bulk, twisting this conductor in such manner, that there is no tendency to kink, even when rapidly paid out. A field cable system was patented by the writer, which has been used with the R.E. Field Telegraph Corps since 1888. The weight of cable per mile became reduced to 77 lbs. against 300 lbs.; and the breaking strain raised to 500 lbs. against 181 lbs. of the old cable used before 1881. The insulation as stated in the "Manual of Instruction in Army Telegraphy," measures, wet, after one hour's soaking in water, about 1,140 ohms per mile.

These lighter cables make it possible to use now waggons with 2 instead of 4 wheels, driven by 4 instead of 6 horses; each waggon carrying 8 instead of 3 miles of the type used before 1881, or instead of 5 miles of that used before 1888. The rate of progress with 2 carts is from 5 to 6 miles an hour on ordinary roads, and about 8 miles an hour in open country. Colonel Beresford, R.E., says in a paper read before the Royal United Service Institution: "We are not now uncertain of our field lines as we were in years gone by, when our equipment was of inferior material. There is now a cable in our service, weighing 77 lbs. per mile, that will stand a strain of 500 lbs., that I have frequently seen passed over by artillery and remain intact. In the vibrating sounder we possess an instrument which in combination with a telephone will transmit signals through bare wire laid on the ground, and even in water."

The success which has hitherto attended field telegraphs in war will naturally greatly increase with the more modern equipment, and the telegraph can now with certainty keep pace with advancing cavalry, a feat which the Field Telegraph Corps often performed, and which was again most successfully repeated during the night marches on the 27th and 28th of last April, when the marching columns were kept in constant communication with headquarters and between themselves. This is the highest state of efficiency, and a palpable proof of the perfection, which the *personnel* and *material* attained during the last 25 years progress of Military Telegraphy in England, and upon which all officers, non-commissioned officers and men, late and present, of the Royal Engineers' Field Telegraph Corps have a proud claim of partnership.

TWENTY-FIVE YEARS' PROGRESS IN SECONDARY BATTERIES.

By L. EPSTEIN, M.I.E.E.

Expectations repeatedly raised to the highest pitch and as frequently disappointed, rash and exaggerated statements, anticipations heralded as facts—on the other hand painstaking experiments, attention to the minutest details, resulting in slow but steady progress; this is the synopsis of 25 years' accumulator work.

As is well-known the electro-motive force of electrodes composed of peroxide of lead was investigated by Schönbein (1838), de la Rive (1843), and Wheatstone (1843), the property of finely divided lead to occlude large quantities of hydrogen was noticed by Sinsteden (1854), while the credit of systematic experiments with lead plates in dilute sulphuric acid for the avowed purpose of utilising the secondary current leading to the general use of this metal for storage purposes, belongs to Gaston Planté.

Although the first results of Planté's studies were published as far back as 1859, it was not till twenty years later, during which interval the improvements in dynamo machines had rendered the generation of electricity so much easier and cheaper, that he resumed his work and fascinated the electrical fraternity by the publication of his interesting researches.

The electrical properties of the original Planté cells were excellent, and compare favourably with most of the modern types, but the process was too slow and expensive to allow its application on a commercial scale.

Faure in 1880, conceived the idea of reducing the cost and increasing the capacity by coating lead plates with a layer of oxides or salts of lead prior to their electrical formation, and holding the paste in place by wrapping the electrodes in parchment paper and felt. The rapid destruction of the separating materials and the formation of sulphate between paste and plate, led however to the disintegration of the active material short-circuiting the cell, defects which were obviated by placing the active material in interstices or recesses of the plate itself, which was done by Sellon and Volckmar.

The Faure-Sellon-Volckmar patents either monopolised or controlled the accumulator industry to a large extent for a considerable period, at the same time it should be ungrudgingly granted that the perseverance and pluck exhibited by these pioneers often in the face of such disheartening disappointments as are only too common in a new industry, deserve the sympathy and praise of everybody interested in secondary batteries.

Faure's invention was hailed in certain quarters with unbounded enthusiasm. It was stated as a remarkable fact that fifty cells, forming part of several tons of Faure's accumulators, which were shipped to America, and had been put on board fully charged, lit during the whole voyage two Edison 8-c/p lamps in the smoking saloon, and a few other lamps occasionally in the engine room and cabin; while M. Philippart, at a General Meeting of the Faure Electrical Accumulator Co., gave vent to his exalted expectation in the following words:—"We look upon ourselves as the sole possessors of one of the greatest inventions of the age. The only practical and economical accumulator is the Faure-Sellon-Volckmar. Everything leads us to believe that it will not be superseded."

For the verification of this prophesy consult subsequent developments.

Suggestions of improvements having for their object mainly acceleration of formation in the case of the Planté type or means of better retaining the active material in the case of the Faure type and its modifications were now forthcoming from many quarters, many of them utterly valueless while a few led the way to important and lasting progress.

Scientific investigations kept pace with and materially assisted practical work, one of the earliest of these useful communications being Prof. Silvanus Thompson's paper, "The Storage of Electricity," read before the Society of Arts in 1881, in which he gave an historical summary, explained the chemical changes during charge and discharge and foreshadowed the future applications of secondary batteries, while amongst other valuable contributions towards the knowledge and chemistry of secondary batteries may be mentioned those of Dr. Frankland, read before the Royal Society, and Mr. Geo. F. Barker, at the Montreal meeting of the American Association for the Advancement of Science. Messrs. Gladstone and Tribe paid special attention to the part played by the sulphate of lead during charge and discharge, culminating in the verdict that this much maligned product—far from being wholly injurious—is absolutely requisite for enabling an accumulator to retain its charge.

Probably the first electric light plant in England in which accumulators formed an important accessory was installed towards the end of 1882 at the Offices of the Electrical Power Storage Company in Old Broad Street, and about the same time the first electric launch in England worked by storage batteries, the "Electricity," made its appearance.

Series-wound dynamos were often used for charging purposes and in order to guard against a reversal of current, automatic devices were inserted in the circuit—not as yet to cut in or out, but only to ring an alarm to attract the attendant's notice.

From the very beginning great expectations were entertained of the suitability of accumulators for traction purposes, and in 1883 experiments were carried out in this country at Aston and Kew and on the Continent in Paris. Many similar attempts were made from time to time, both in Europe and the United States, and although many of these trials were satisfactory from a technical point of view, and notwithstanding most positive statements as to the saving effected compared with horse-traction, it is only now—fifteen years after the first experiments—that the progress made in the manufacture of accumulators offers a fair promise of realising the hopes which have been so long deferred.

Meanwhile the public had become very eager to use this wonderful electric commodity, and the Electrical Power Storage Company not only began to supply this want, but offered a guarantee in which they stated "Where the accumulator is properly used the effective return is 90 per cent. of the electrical energy stored." We have since become satisfied with a lesser efficiency.

Methods were devised for suitable systems of generating electricity at supply stations, and distributing it with the aid of accumulator batteries, and following a suggestion from Sir William Thomson made in 1881, Professor Ayrton in a lecture delivered at the London Institution in 1883, advocated distribution by means of charging a large number of accumulators in series by a small current of high potential, while discharging them in sets of lower voltage. Men of science and practical engineers began to assign to secondary batteries an important part in the future, and Dr. William Siemens in a lecture before the members of The Institution of Civil Engineers, anticipated and advocated their use for tramways and vessels.

Water-power being pressed into the service of electricity, an electric light plant in which hydraulic power and accumulators were distinguishing features, was successfully installed in the town of Nantua (France).

Temporary light installations with accumulators made their appearance, and batteries were used at a soirée at Guy's Hospital, and at a conversazione in connection with the meeting of The Iron and Steel Institute, at Middlesborough, in October, 1883; while in January, 1884, electric lamps affixed to the "fairies'" heads at the Drury Lane Pantomime, worked by small portable batteries, dazzled the audience.

The lighting of railway carriages was inaugurated. Trains between Victoria and Brighton, in 1882, followed some years later by the New York and Washington line in the United States, and the trains between Frankfort and Fulda in Germany, were the pioneers—the storage batteries being placed in the guard's van, while in the experiments carried out in 1885, on the Lancashire and Yorkshire Railway, each car carried its own complement

of batteries, in order to maintain the light in case of the train being broken.

About the middle of 1883, experiments with secondary batteries on telegraphic circuits were made at the General Post Office, under the auspices of Mr. Preece, the electrical engineer-in-chief, with satisfactory results.

The following passage in a letter written in March, 1885, by M. Gaston Planté to a friend who was using one of his batteries in England may prove interesting. "The plates, far from deteriorating with age (like those to which artificial layers of peroxide have been applied), become penetrated under electrolytic action more and more deeply with peroxide, which unites with them perfectly, without any danger of the plates losing their solidity." The results of 12 years' practical experience have shown the correctness of Planté's opinion.

By the beginning of the year 1885 many of the exaggerated expectations regarding secondary batteries, such as their durability and economy for tramway work, the simplicity of their treatment, and their reliability in unskilled hands, had met with disappointment, and the futile attempts at grasping brilliant successes by one bold and fortunate stroke were now succeeded by a period of patient and unremitting labour, resulting on the whole in steady progress, the very failures and disappointments offering a fresh incentive for further efforts, and forming very often the stepping stones which led to ultimate success.

Domestic lighting plants, in which accumulators played an important part, multiplied all over the civilised world.

The Edison Swan Company in New York, who had previously strenuously opposed the use of secondary batteries, now (1887) advocated their adoption, but another six years elapsed ere a secondary battery plant was connected to the mains of one of the Edison stations in New York.

The importance of improved mechanical construction forced itself upon the minds of accumulator makers, and the necessity of using devices of such a nature as—while keeping the electrodes of opposite polarity well apart—did not allow any fallen off material to cause internal electrical leakage, led to the adoption of more suitable arrangements by leading manufacturers. At the same time the value of the specific gravity of the electrolyte as an indication of the state of charge or discharge of a cell became more generally appreciated.

Accumulators having been extensively and successfully used in connection with isolated plants for several years, their installation in central supply stations was now decided upon in England, while in the United States they had been used apart from many private plants for about two years at central stations in many of the smaller towns; and in Germany the first electric supply with accumulators as an accessory was instituted in Frankfort by none other than the Gas Company.

The municipal councils of several large German towns took the lighting schemes into their own hands, and large sums were set aside for the purpose, installations comprising from 8,000 to 30,000 lights being decided upon, and the movement extended to other Continental towns.

Again, the project of running tramcars with accumulators was taken up in different countries, and sanguine estimates were based upon the results of the first few trial runs. We may mention Reckenzaun's experiments with a car in 1886 in Berlin, for which he imported the accumulators from England, and the competitive trials made at the international exhibition at Antwerp between tramcars driven by steam, compressed air, and electricity stored in accumulators, with apparently very favourable results for the electrical system.

In April, 1885, a car with Julien accumulators commenced running in Brussels; two more cars were added in the same year. They ran in 1887 alone 34,000 miles, but the financial results were unsatisfactory, owing to the rapid deterioration of the batteries, and after five years' unsuccessful attempts to make the service pay, the experiment was discontinued in 1890, and horses reinstated.

We must not forget the experiments which were started with accumulator cars on the Birmingham Central Tramways in 1888, as this line was destined to hereafter become the playground and battle-field of so many rival systems.

The movement extended even to our antipodes, an electric tramcar worked by accumulators putting in an appearance at South Yarra, in Australia.

The accumulator car did not, however, confine itself to tramway tracks, for in 1889, the first electrical omnibus was run with success by Mr. Radcliffe Ward, to be shortly followed by a parcels delivery van.

While the number of electric launches on the Thames had gradually increased, the largest being "The Viscountess Bury," which, with its length of 68 feet, has up to the present maintained its position with regard to size, it was but natural that a motive power requiring no fire and giving off no noxious products should recommend itself for propulsion under water, and a number of experiments with submarine boats driven by accumulators were tried. A boat of such description was run in Liverpool in 1886 with complete success, and another in the following year in France, the results inspiring the Paris *Figaro* with the prediction that "this invention is destined to give France the Sovereignty of the Seas."

For telegraphing accumulators had proved eminently satisfactory, and batteries having been employed to a considerable extent at the Central Telegraph Station in Berlin since 1888, a further increase was decided upon.

Scientific investigations again came to the assistance of the practical workers, among the most noteworthy being Professor Ayrton's paper "The Working Efficiency of Secondary Batteries," read in 1890 at the meeting of the Institution of Electrical Engineers at Edinburgh, in which were embodied all those precautions as the then state of the batteries rendered indispensable for satisfactory working, and of such a practical nature that the instructions which related to the necessity of charging at low rates, avoidance of rest and guarding against leaving cells in a discharged state, even for a short time, were almost generally adopted.

Soon hereafter, however, such progress was made in the manufacture of accumulators, more especially of an improved Planté type, that their robust construction rendered such precautions unnecessary, and Professor Ayrton himself as the result of lengthy tests was the first to acknowledge the fact.

For the guidance of attendants of private installations which had increased to a large number, Sir David Salomons published in 1886 a practical handbook "On the Management of Accumulators," which has since seen many editions and proved of real service.

Another important application for accumulators is that for electric welding. By the Benardos system the piece to be worked is connected to one pole and a carbon rod to the other pole, thus forming an arc. Messrs. Lloyd and Lloyd at Birmingham introduced this system at their works in 1890.

By the beginning of the year 1894 storage batteries as auxiliaries in central stations had been working a sufficient number of years to justify the wisdom of their adoption; they had proved economical and of an average efficiency of about 80 per cent., and as their lasting properties were satisfactory, makers were emboldened to enter into maintenance contracts at moderate rates.

Two interesting and large installations of accumulators on tramcars, which denote new methods of working, are those in Paris and Hanover.

On the Puteaux line in Paris the batteries, which are of sufficient capacity for the day's total run, are recharged during each stoppage at a terminus, the time varying between 12 and 20 minutes, and the charging being effected not as was usual hitherto at a constant current, but at a constant voltage. It has been found possible by this method to recharge the batteries within a short time, 50 per cent. of the total charge being restored within the first hour, 75 per cent. at the end of the second hour, and 83 per cent. at the end of the third hour, and the advantages claimed are more rapid charge, prevention of overcharge, and less wear and tear of batteries.

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On the Hanover line a mixed system of trolleys and storage batteries is used. It was determined in 1895, when the first accumulator car started running, to try the experiment of charging the accumulators during the journey from the existing overhead conductors. At the beginning of 1897 there were about 12·8 miles of tracks with the overhead conductors, and 10·6 miles worked by accumulators. The charging is effected over distances varying from 1·7 to 4·8 miles, the discharging taking place over distances from 3 miles to 7·2 miles, but as there is not sufficient pressure at all parts along the trolley wire a supplemental charge is given after the car has returned to the shed. Each car carries 208 cells; when the battery is switched on, they are first arranged in two halves in parallel with resistance inserted, then the resistance is gradually cut out, and finally the two halves arranged in series. The financial results of this line, according to official reports, are favourable, as taking everything into consideration, the extra cost of accumulator traction as compared with the trolley system does not exceed one-tenth of a penny per mile.

The possible improvements for obtaining the maximum capacity and discharge rates in an accumulator pointed from the beginning in three directions: with the pasted types to an increase in the volume of the active material compared with the grid or other support, with Planté types to the highest development of surface compatible with the required mechanical strength, and to chemical preparation with a view to more rapid electrical formation.

Actually, we see in the listed types of the first-named class that the weight of the active material has considerably increased with a corresponding reduction of the support; but as the latter offers no longer the necessary mechanical assistance, other devices had to be resorted to, such as enclosing the electrodes in porous or perforated envelopes.

Again, the importance of using the active material in a highly porous condition, so that the electrolyte may have free access into the interstices of the plates being recognised, while material of such description is naturally liable to more rapid disintegration, binding materials of organic or inorganic origin are used by some makers.

How far and for how long these mechanical or chemical remedies will fulfil their purpose, only further time can prove.

Alloying the lead with some other metal and eliminating the latter subsequently was another means frequently suggested, patented and tried; but with one notable exception these means have been abandoned, probably by reason of the difficulty of removing the last traces of the foreign substance, the presence of which proved detrimental to the satisfactory working of the cell.

As regards accumulators of the Planté type, expedients for obtaining an increase of surface were mainly twofold, namely, either making slabs of lead particles while the latter were in a crystalline state, or simply using ordinary metallic lead offering a large surface in the form of lead strips with or without a central web.

The chemical treatment alluded to consists in either subjecting the electrodes prior to their formation to the action of some suitable corroding agent, or adding the latter to the formation electrolyte. Some of these processes have been found highly satisfactory, while others, after giving excellent results for a number of years, were subsequently abandoned.

Great expectations were raised at one time by the "Waddell-Entz" alkaline accumulator, a derivative of the Lalande-Chaperon primary couple, with its positive electrode of finely divided copper, highly compressed, and its negative of electrically deposited zinc, in a solution of caustic potash. Batteries of this type were tried with apparent success for tramways and submarine boats, their weight comparing favourably with existing lead accumulators. It appears, however, that unforeseen difficulties were encountered, and very little is heard of this type now.

We meet the storage battery to-day in almost every branch of applied electricity as a well recognised and duly appreciated commodity.

Thousands of private electric lighting plants and hundreds of central supply stations testify to their utility and economy, and for electrotyping, telegraphing, telephoning, and many other purposes, they form valuable adjuncts.

Embodying as they do the ideal form of traction, the objection to their use on the score of expensiveness—which was only too well founded in years gone by—is being gradually overcome, thanks to the improvement in the manufacture and the better understanding of the treatment, and the latest financial results obtained in Hanover seem to prove that they have entered the era of economical success.

Large numbers of electric launches easily navigated compare favourably with their steam or oil rivals, and the black and yellow electrical cabs are daily becoming a more familiar sight in the London streets.

Although no sudden startling evolution has marked the history of storage batteries, it will be granted that very substantial progress has been made. The force of facts has converted opponents into allies, while the current of public opinion flows strongly in their favour.

ELECTRICAL INSTRUMENT MAKING DURING THE PERIOD 1872-1897.

By W. A. PRICE.

The designers of our present instruments are so numerous that no review of this length can attempt more than to describe the general course of their progress, and though some important inventions demand and receive our independent notice, we cannot help recognising that much valuable and original work does not receive proper justice at our hands.

In 1872, telegraphy was the only electrical art that was well developed, and much of the apparatus then in use in England differed little from that employed now. Wheatstone and Siemens had long before produced their A B C instruments, and the former had developed his system of automatic transmission nearly to its present form. The use in telegraphy of a moveable soft iron armature magnetized by a large permanent magnet in its neighbourhood was well recognised, and employed in the dials of Varley and Spagnoletti, and in the relays of Siemens and Wheatstone. The standard relay was the accepted form of the postal telegraph service. The Siemens Morse inker was in use all over the world, and Bright had introduced his acoustic system with two bells. Duplex telegraphy was in common use.

The last twenty-five years has replaced the Morse inker in England by the sounder, introduced from America about the beginning of our period. Quadruplex telegraphy, perfected about 1876, has become the rule on busy lines. Wheatstone's automatic apparatus in the hands of the engineers and mechanics of the postal telegraph service has attained a speed of working unattempted at first. Delany's multiplex, brought out in America in 1884, and described by Mr. Preece before the Society of Telegraph Engineers in April, 1886, has enabled telegraphists to largely increase the carrying power of a line with ordinary instruments and operators. Major Cardew's vibrating sounder, invented for use in field telegraphy in 1881, was described before the Society of Telegraph Engineers in 1886. The Hughes' printing telegraph, which has been largely employed on the continent, has come into use in England since the recent acquisition of the Channel cables by the Government; and the Exchange tape printing instruments, introduced from America in 1874, are now found in hundreds of clubs and offices.

In the English telegraphic service the history of twenty-five years has been rather one of perfection of construction and detail, than of marked advance in method.

In marine telegraphy, Lord Kelvin's syphon recorder, with a moving coil, has come into use on every long and busy cable, and within the last few years has been

greatly improved by Dr. Muirhead. His system of curbing signals, described by Prof. Ewing before the Society of Telegraph Engineers in 1876, was for many years supplanted by the invention of condenser signalling, which produced a nearly identical result with simpler means; but now that commercial pressure demands increased working speed from existing cables, telegraphists are again resorting to the refinement of a curbing system. Dr. Muirhead, by the construction of artificial cables closely identical in their electrical qualities with real cables, has duplexed lines so perfectly as nearly to double their working capacities, compared with simplex telegraphy. The Allan-Brown relay, using the moveable tongue invented long before that date, was introduced in 1878, and has proved of service on many lines. Mr. Jacob designed an instrument in 1885 on the same principle but of greatly refined construction.

In reviewing the advance in construction of measuring instruments, the question of the original standards naturally takes the first place. In 1872 the British Association Committee had defined the ampére, the ohm, the volt, and the farad, and had constructed the apparatus for the measurement of such quantities. They had ascertained, with indifferent accuracy, the resistances of certain material conductors, the electromotive forces of certain cells, and the capacities of certain condensers. But the values of the two former of these depend directly on the determination of the ohm, and this has since been replaced by a new value, the mean of many independent and nearly concordant measures, made by different methods and observers. The value of certain concrete resistance coils stated in accordance with this determination have been adopted by the Board of Trade as the unit for the construction of contracts, and of their own orders. They have defined the ampére for the same purposes in terms of the constant of a certain electro-dynamometer in their possession, and the volt in accordance therewith. They have stated the electromotive force of a Clark cell, made up according to a certain recipe, and this cell with copies of their resistance coils are the accepted standards for all electrical measurements in England.

But the question of the standards is not in a satisfactory condition. The stability of the platinum-silver alloy used for the construction of the standards of resistance is not beyond all doubt, and causes grave mistrust in some minds; while other alloys largely used for secondary standards are admittedly not permanent. Professor V. Jones would persuade the world to replace their material primary standards by copies of the Lorenz apparatus, but the discrepancy between the results obtained from his machine at Cardiff, and from that recently constructed under his superintendence for the McGill University, is at present an obstacle to this.

Many new alloys have been proposed for secondary standards of resistance and for coils for ordinary use. German silver was gradually replaced by platinoid, which is itself now in discredit. Manganin has been put forward by the officers of the Reichsanstalt, and has the great advantage of a small, sometimes negative, temperature co-efficient, while other materials, many being alloys of nickel, are in the market under different fancy names. New forms of coils have been designed by Prof. Fleming and others, and Mr. Crompton has constructed conductors of very low resistance to carry large currents for use with the potentiometer, which are kept cool with a current of water.

The Clark cell has come into universal use as a standard of electromotive force. Mr. Hibbert's chloride cell, which can be adjusted to give an E.M.F. of 1 volt exactly, and has an extremely small temperature co-efficient, promises to be very convenient.

Standards of current, or current gauges, have been designed by Lord Kelvin, and are likely to come into extended use. The possession of standards of three kinds, of resistance, current, and electromotive force, capable of inter-comparison, supplies an useful check on the constancy of each.

The commercial demand for direct reading instruments measuring current and electromotive force has produced a great many forms. Since 1881, when Profs. Ayrton and Perry read a paper on the subject before the Society of Telegraph Engineers, nearly every instrument maker has designed one or more instruments depending on the movement of a piece of soft iron in the field of a solenoid against the control of a spring, weight, or permanent magnet. Such instruments when controlled by a spring or weight suffer more or less from errors of hysteresis; and when controlled by a permanent magnet are liable to error from changes in its intensity. The use of electromagnets excited by a constant battery, or by the current under measurement, proposed by Mr. Crompton in 1884, has not been largely adopted. All these suffer to a greater or less extent from indifferent scales and a want of dead-beatness, or they consume an excessive amount of power. Some of the best known forms are Lord Kelvin's recording instruments, his current gauges, and marine instruments, and Messrs. Evershed and Vignoles' volt and ampére meters.

A well known instrument, the Siemens Ampéremeter, described by Mr. Alexander Siemens before the Society of Telegraph Engineers in 1887, measures the tension of a spring required to hold a moveable soft iron piece in a definite position against the action of a solenoid, the field and iron being of a very peculiar form. This valuable instrument is not read by inspection but by adjustment, and is unsuitable for many purposes.

An arrangement of exceptional interest calls for special notice. The Ayrton and Perry Spring, described in February, 1884, is a device for developing a large angular movement about an axis from a small displacement along it. Equivalent kinematically to a nut and screw of very short pitch, it is wholly free from frictional error. The discovery is applicable to many kinds of measuring instruments, but its immediate use by the inventors for indicating the small movements of an iron core drawn into a solenoid brings it into this part of our subject.

An instrument of a totally different kind for the measurement of current is due to Major Cardew. The elongation of a fine wire heated by its passage is used to measure a small current of electricity. Exceptionally cumbrous in form, and delicate in construction, it is accurate in indication, has a large and open scale, and is perfectly aperiodic. It has proved to be one of our most useful instruments. An interesting combination of a hot wire with their helical spring was described by Profs. Ayrton and Perry in 1887. All the hot wire instruments absorb considerable amounts of energy. Major Holden and Messrs. Drake and Gorham, have introduced recording ampéremeters, depending for their action on the unequal extension of two different metals when heated by the current to be measured.

A type of instrument in which a coil of wire carrying the current to be measured moves in the field of a permanent magnet is largely used for portable and station work. The principle is old, and was applied to galvanometers long ago; but doubt of the constancy of the permanent magnet has, no doubt, delayed its introduction into direct reading instruments. An American, Mr. Weston, has in recent years produced instruments which are widely used and trusted, and if the magnets are permanent leave nothing to be desired. They absorb little energy, have excellent scales, are perfectly aperiodic for most purposes, and convenient in form. Prof. Ayrton and Mr. Mather have since designed an exceedingly good station voltmeter of the same kind with an astatic coil and a gravity control, and Messrs. Muirhead & Co. another, with a very extended scale.

An instrument which balances the weight of a certain mass against the mechanical action on one another of two coils carrying the same current, must remain the primary standard of reference. Where the forms of the coils closely approximate to simple geometrical figures, so that the coefficients of induction can be calculated, the instrument is absolute, and gives direct determinations in C.G.S. units. Even where the coefficients of induction cannot be calculated, the peculiar quality of the instrument remains: viz., that its constancy depends solely on retention of form, and is unaffected by molecular change in the materials. Lord Kelvin has introduced a series of such instruments, called "standard

balances," standardized by experiment, but having computed scales, which are now relied on for accurate measurements of current, and the calibration of other instruments. He has constructed a series of these capable of usefully measuring currents from ·01 to 2,500 ampéres, in close agreement with one another throughout. They were first described in May, 1888, and were the object of constant study for some years before and after that time.

Of the instruments for the measurement of current that have been referred to, many, when constructed with a circuit of nearly constant resistance, are used for the measurement of electromotive force; but instruments for this purpose depending on the mutual attraction of two oppositely charged plates of a condenser have great advantages. They can be used either with direct or alternate current systems, they absorb no energy, and require no correction for temperature. Lord Kelvin has introduced a series of electrostatic voltmeters, constructed on the multicellular principle, with bifilar suspensions, for forces ranging from 40 to 20,000 volts; and electrostatic balances on knife edges from 5,000 to 100,000 volts for very high differences of potential. Prof. Ayrton and Mr. Mather and Mr. Swinburne have also constructed electrostatic voltmeters suitable for switchboards.

In 1872 the principal galvanometers in use were the sine and tangent galvanometers, Lord Kelvin's reflecting instruments, and for absolute determinations the electro-dynamometer. The theory of the tangent galvanometer had been very fully investigated by mathematicians to ascertain the law of its scale, and indeed the theory of the distribution of the field of a circular coil is the foundation of the absolute determinations of all the electromagnetic values. The improvements of Gaugain and Helmholtz were known at that date. In 1872 Sir William Thomson described his series of graded instruments, which applied the principle of the tangent galvanometer to the intercomparison of currents over a great range, and were supplied with data for obtaining the absolute values from the scale readings. The production of this series undoubtedly marked a very important step in electrical work. Little attention has since been given to the construction of tangent galvanometers, except by Dr. Obach, who described in 1883 instruments of his design having coils capable of rotation about the magnetic axis of the needle in its zero position. The tangent galvanometer has since then been generally superseded by more convenient instruments.

The Thomson reflecting galvanometer having a magnetic system moveable near fixed coils, has practically remained in the form in which it existed in 1872. Attempts have been made in many directions to improve the instrument, but without marked success, except by Mr. Vernon Boys' discovery of the singular properties of the quartz fibre. Its freedom from elastic fatigue has removed from instruments a source of error that seemed insurmountable, while the tendency of a water film on its surface to contract into drops renders it peculiarly suitable for an insulating support. In view of the future the discovery is the most important made in our subject during the period under review.

The principal feature in the history of the galvanometer during twenty-five years is the introduction of the suspended coil instrument. The principle has been repeatedly used by physicists since its discovery by Faraday, but the first commercial instruments in England were those described by M. M. Deprez and d'Arsonval in March, 1883. From this rather crude and insensitive design have been developed by Prof. Ayrton, Mr. Mather, Major Holden, and Mr. Sullivan, instruments which surpass in every way the best instruments having fixed coils and suspended magnetic systems. Mr. Sullivan's recent application of this type of instrument to marine work on cable ships and war ships has greatly lightened electrical testing in those unfavourable conditions. Much information has recently been given by Prof. Ayrton and Mr. Mather in their published papers on the details of construction that have enabled them to obtain their results.

The universal shunt box described by these authors in March, 1894, and the shunt arrangement for ballistic galvanometers, described at the meeting of the British Association this year, are of capital importance in their branch of this subject.

In apparatus for the measurement of resistance, there is no conspicuous step to note. Wheatstone's bridge was known long before 1872, and the plug resistance box for general use, and the slide wire bridge for the comparison of nearly equal quantities were in use at that time, though new arrangements of the last instrument offering special conveniences for very rapid and accurate work have been designed by several persons. Excepting that greater refinement and accuracy are found in the construction of coils for resistance boxes, and that more sensitive galvanoscopes are used, little change has been made.

The ohmmeter, described in January, 1884, by Profs. Ayrton and Perry, and brought into practical use by Mr. Evershed, owes its importance to the fact that the quantity required is read directly from a scale, with the simplest possible manipulation. It is not capable of much exactness.

The name potentiometer indicates rather a system of electrical testing than any particular instrument, though it is somewhat identified with a set of apparatus due to Mr. Crompton and Mr. Fisher. Prof. Fleming was the apostle of the potentiometer many years ago. Its essential feature is the use of a long conductor the whole or part of which is minutely subdivided at points of contact into sections of equal resistance. The slide wire of the Kirchoff's bridge is an appliance of the kind, and the Thomson and Varley dials, designed for cable testing, are a refined example. Mr. Rymer Jones has recently designed an improved set of dials, having certain advantages over the older pattern; and Messrs. Elliott Bros., and before them Messrs. Nalder Bros., designed complete potentiometer sets in convenient forms. The system has many advantages for the measurement of such large conductivities and currents as occur in electric lighting work and dynamo construction, the recognition of which is largely due to Mr. Crompton's advocacy and example.

An investigation by Professors Ayrton and Perry of different methods of measuring inductance led to the invention of the Secohmmeter as an adjunct to the Wheatstone's bridge, and the proposal of the name Secohm for the commercial unit of inductance, a length nearly equal to the earth's quadrant. This interesting instrument, described in 1887 before the Society of Telegraph Engineers, is used to measure the apparent increase in the resistance of an inductive circuit, balanced on a Wheatstone's bridge, when the usual steady testing current is repeatedly interrupted in some known way. The apparatus does not conveniently deal with the problems of inductance in iron magnetic circuits, which are at present the most important and interesting cases that occur in practice. Adjustable coils of known self and mutual inductance have been designed by the same professors for use with this and similar apparatus.

Prof. Ewing's name is closely associated with the measurement of the magnetic property of iron, to which he has given the name hysteresis. To him is largely due the general recognition of the character and commercial importance of this property, a conception of the molecular action in the iron which gives rise to it, and a series of instruments for its investigation and measurement. His magnetic curve tracer, hysteresis tester, and magnetic balance, are among the most useful of the many pieces of apparatus that have been designed by those who have studied the magnetic properties of iron.

The instruments we have noticed are however only a small selection of the more exact kind from the immense variety that have been produced. On the scientific side Hughes' induction balance, Vernon Boys' radio-micrometer, Lodge's oscillators and coherers, Röntgen tubes and screens, Tesla's induction coils, Wimshurst's electrical machines, are the fruit of the period of our review; while on the commercial side, fire alarms, ship's telegraphs, railway signalling instruments, water level indicators, time signals, mine exploders, writing tele-

graphs, electrical organs, meters, lightning protectors; in all interesting advance has been made. The last 25 years has been a period of extreme activity in all directions, and the commercial value of many developments has placed resources at the disposal of electrical instrument makers that they have not been slow to use. One serious drawback has been and is still felt. The unmechanical character of much of the material employed, and the possibility in many cases of obtaining an immediate result with the simplest means has tempted the production of slovenly work. But we may hope to have seen the last of the bits of paper, and string, and gum, and wire, and mica, of twisted joints, and loose screws, that disfigured much of the older work. The determination of standard screws, and plugs; the increasing use of small milling machines, sensitive drills, and accurate watch makers' lathes; the care given to drawing and covering fine wires, and the competition of the best firms of Sheffield and Birmingham to provide electrical mechanics with materials; all are assisting to raise the character of the work. We may fittingly close this short review with an acknowledgement of the debt we owe to the Postal Telegraph Service, the largest users of electrical instruments in England, for the high standard of mechanical workmanship they have consistently maintained.

THE PROGRESS OF ELECTRO-CHEMISTRY AND ELECTRO-METALLURGY DURING THE LAST 25 YEARS.

By EMILE ANDREOLI.

We are so accustomed, nowadays, to hear of the marvels of electricity, that we find it quite natural to take advantage of and benefit by them; it hardly seems credible that there was a time when nothing was known of the fairy-like doings which contribute so largely to our well being, and which it would now be so hard for us to be deprived of. It goes without saying that 25 years ago we had no electric incandescent light, no telephones, and no electric traction. How far were we advanced with regard to electro-chemistry, and the applications thereof? The following extract from a report on the Paris Universal Exhibition of 1878, will give an idea of the state of advancement existing at that time:—

"Electro-metallurgical processes give rise to products more and more varied and numerous; the chief processes for the deposition of metals are the same as in 1867. A few batteries have been invented to render the production of the electric fluid more economical; the most marked progress has been in the preparation of moulds, and in the better arrangement of the apparatuses."

The only thing worth mentioning is that a few years before, Elmore had already been forestalled by Fedorovsky, inspector of the galvano-plastic establishment created by the Russian Navy Ministry at Cronstadt, where he had made, by galvanic methods, seamless straight tubes, and tubes with single and double bends, also without seams.

At the Electrical Exhibition in 1881, electro-chemistry was only represented by articles coated with copper, silver, nickel, zinc, iron, lead, tin, cobalt, tungsten, &c., and by some fine specimens of etchings produced by the galvanic current; but this was already a step forward, for the objects and reproductions displayed had mostly been obtained with the aid of Gramme, Siemens, de Meritens and other dynamos. More particularly were the electrolytical products of the *Norddeutsche Affinerie Actiengesellschaft* to be noticed, such as gold, copper, and silver in a chemically pure state, laminated plates and drawn wire made of copper without seams or joints. It was marvellous—at that time—to see the exhibits of a factory which, with six Gramme dynamos, turned out 550 tons of copper per annum. How far ahead of this we have got, now that in America 40,000 tons of electrolytical copper are produced for wires and cables only in one year.

The start was made many years ago with gilding and the deposition of silver and copper, but to-day there is no metal which cannot be deposited electrolytically. Electrolytic goldsmith's work has given, and does yield every day, masterpieces of work which the most skilful artists of the Middle Age and of the Renaissance periods could never have produced. The industrial applications of electro-deposition are no less remarkable than its applications to art. It is as equally useful to statuary, sculpture, and to the art of coating large surfaces with metal, as to the reproduction of small objects, and it can now yield metallic layers of almost any desirable thickness. Just look at the splendid pictures which are so plentiful in the books and publications of to-day. In the course of a few hours any drawing or photographic view can be fixed on metal by the electric current and reproduced in the press. The very finest lines and the most minutely executed maps of the Ordnance Department are obtained from the electrolytic stereo, which can furnish us with hundreds and thousands of copies. It will never be known what good service has been done by the aid of electro-deposition, and to what extent it has popularised the arts, science, and literature.

The extraction of zinc from its ores, and especially from its rebellious ores, has been attempted by numerous industrious and hard-working toilers; several of their processes are to be found described in books, but either they have for many years been abandoned, or else they have never been worked on a commercial scale. In Australia, the argentiferous blendes from Broken Hill (we mean by this their solutions) are at the present time electrolytically treated by two methods, one of which is due to the Ashcroft Company, and the other to Messrs. Siemens & Halske. The latter succeeds remarkably, it appears, in producing very cheaply a splendid deposit of zinc in a very pure state. Electro-metallurgy is carried out at Broken Hill in an immense installation, and the yield of metal is at the rate of several thousand tons per quarter.

There are several establishments in Germany and other countries where electro-deposition of zinc is effected. In England, zinc is deposited by the Cowper-Coles process on the hulls of ships and torpedo boats, on anchors, rivets, bolts, chains, cables, pipes; and the fineness of the grain, the firmness of the coating, and the rapidity with which the work is done, together with its cheapness, leave nothing to be desired. Galvanisation, as it was done formerly, has seen its best days; true galvanisation, the one produced by the current, has superseded it.

With the exception of lead, what metal is there which is not, or cannot be, deposited? and still, by means of Tommasi's method, metallic lead is obtained, which, we are told, is everything that can be wished for, both as regards quality and quantity.

These electro-metallurgical applications recall to our mind what Becquerel, in the preface to his "Eléments d'Electrochimie," said, over 50 years ago, when referring to the electro-chemical forces, by the aid of which metals can be extracted from their ores:—

"In the presence of such facts, the importance of which one is led each day to appreciate more and more, it is easy to realise all that the future reserves for the utilisation of such a force, the agency of which is, one might almost say, infinite, which exists chained up and silent, so to speak, wherever matter exists, and will, perhaps, some day obtain a complete mastery. That time is still, in truth, far away; but let us, from the present day, set about preparing for our great grandchildren the ways and means of extracting metals from their ores."

The space at our disposal in which to describe, even at a glance, the developments of electro-chemistry taken as a whole, and of its applications, is so small, that we must make excuses if we only succeed in making brief sketches, and in confining ourselves to the principal and most important questions. Anyone who a few years back would have recommended a young fellow to take up electrolysis as a profession, would have been considered to be a bit eccentric, or even not to be quite right in his head. There was hardly any future for anybody that way, for, apart from galvanic metallic deposition, no electro-chemical industry existed. Even now, it is of all the branches of electricity, the least encumbered, but it is the one in which a young man has the best chance of securing a good position. He will not, however, make much progress if, although a good

electrician, he is but a poor chemist; whereas it will be the very opposite if, being a good chemist, he has no very great acquirements in electricity. Electrolysis and electro-metallurgy are, nowadays, professions in themselves, and special dynamos are being constructed every day, installations of numerous tanks, sometimes of huge dimensions, are made, carbon electrodes, porous partitions are manufactured; in fact, quite a lot of materials are regularly supplied for electrolytic purposes which were unheard of 25 years ago, and the want of which was not in the least felt. Not only are there electro-chemists and electro-metallurgists to be found at the present time, but there are also consulting engineers who confine themselves to electrolytical matters, experts who make it their special business to draw up reports on new methods, or to give advice as to the best means of applying them. Who, even 10 years ago, could have foreshadowed this state of affairs? The books treating on electrolysis are very numerous, but little known. Since the beginning of the century it has been the aim of the researches and experiments of some of the most illustrious scientists. It would be a noble enterprise to collect and reprint all the writings, papers and pamphlets which are scattered in all the scientific reviews and periodical publication of the libraries.

With the exception of a few works treating on electro-chemistry and electro-metallurgy, there was no literature on those subjects 10 years ago. From a theoretical, as well as from a practical point of view, we can now say that all electrolytical problems have been studied, elucidated, and explained; learned professors have described and taught the principles, the laws, and the applications of electro-chemistry, and we possess to-day many treatises on this new science, and on its industrial applications.

Monographs, descriptions of researches carried out in laboratories on special questions relating to the electrolysis of inorganic or organic compounds, may now be counted by hundreds, and all these, if gathered together and classified, would form a splendid collection—a grandiose monument, which would remind one of the first steps and rapid industrial developments of a branch of electrical science, which, as an industry a quarter of a century ago, was hardly thought of, and which, I intentionally repeat it, apart from gilding, electro-plating, and coppering workshops, existed only in the theories of scientists.

Only those who have carefully followed the progress which has taken place in the domain of electrolysis, can form any idea of the magnitude of the efforts, the unflagging energy and studious researches of the workers who have created this art and industry. How many have been the brilliant prospects and hopeful dreams? And then came the disappointments—nay, the cruel discouragements caused by frequent failures: bitter deceptions were in store for the majority of them. Take, for example, the production of chlorine and caustic soda by electrolysis. Just count the names of those who, ever since 1872, have sought after what, to them, has been a chimera, and which, for one or two, at all events for very few of them only, has been, or will be, a reality. Years of continuous labour have been devoted by them one after another, turning over their ideas in their heads, thinking out various combinations of apparatus and appliances of all sorts, and finally coming across a difficulty which they could not surmount. It is no doubt the defects in their methods of working which have taught others to follow another path. It is almost invariably those soldiers who lead the attack who are the first to fall, but they have paved the path to victory for those who are to follow. To-day there are, here and there, works in which chlorine and caustic soda are produced, but there is one process only which is really carried out on a large scale and which is worked with complete success. We allude to the Castner-Kellner, a 1,000-H.P. plant of which was started about two months ago. A second one of 1,000 H.P. and another of 2,000 H.P. are in course of erection, making a total of 4,000 H.P., and it is expected that all will be completed by the month of July, 1898. Three other large works will shortly be in full working order on the continent, and the enormously large installation of the American Mathieson Co. at the Niagara Falls, will commence operations this month in the manufacture of bleach and alkalies.

These figures speak for themselves, and do they not show the triumph of electrolysis? These grand results are a great encouragement for those who are working in that field. We expect to see the Hargreaves process very shortly carried out commercially and that also with complete success.

It is hardly necessary to state on how large a scale chlorate of potash is now produced in Switzerland, America, and other places, by means of electrolysis. Do our readers recollect a meeting of the "Society of Chemical Industry" when the High Priests of Chemistry condemned and excommunicated the heretic "Electrolysis"? One of these, although a man of real talent and of progressive tastes, after having stated that the production of chlorine and caustic soda by the decomposition of sodium chloride by means of the electric current would never be seen carried out, ironically narrated how he had met an inventor who made out that he could make chlorate of potash in large quantities and cheaply. This greatly amused his listeners, and the meeting dispersed, everyone being convinced that the electrolytic manufacture of chlorate of potash stood no possible chance of success. In scientific and industrial, still more than in political matters, it is dangerous to play the part of prophet.

It has taken electro-chemistry a long time to establish its rights of citizenship in the realm of chemical industry, but it is to-day an accomplished fact, and in very many cases the electric current has been used to substitute chemical methods.

This is an evolution teeming with fecund and profitable possibilities. The old processes have been simplified; the products are now obtained of a better quality and in much less time, and, what is most important, the hygienic conditions in which the men work have been considerably improved.

It would take too long to enumerate all the instances where the electrolytic tank has been used, either for oxidising or reducing purposes. Electro-chemistry enables us to obtain colouring matters, to turn out artificial perfumes, iodoform, chloroform, ferrocyanides, permanganates, bichromates, iodine, bromine, &c.; but the most numerous applications of electrolysis are without doubt those which are made in works without anything being said about them, or in laboratories where experiments are repeated on comparatively small quantities until it is absolutely certain that it is possible to reproduce them industrially under conditions of purity, rapidity and cheapness.

Do we mean to say that there are no incredulous persons, obstinate sceptics, who will not admit that the reign of electricity has commenced in chemistry, or that there can be any alliance between the two? A large manufacturer and great chemist finished his opening address last year to a well-known scientific society by the following memorable words which go to prove how far prejudice is ingrained in certain minds:—"I do not believe that industrial chemistry will in future be diverted from this section, and have to wander to Section A. under the aegis of applied electricity. I do not believe that the easiest way of effecting chemical changes will ultimately be found in transforming heat and chemical affinity into electricity, tearing up chemical compounds by this powerful medium, and then to recombine their constituents in such form as we may require them."

Many other possibilities and truths have been denied, and in spite of the anathema, of the denial of the progress made, electro-chemistry has established its proofs, its rights, has secured a footing which nothing can make it lose, and the facts accomplished will give the lie direct to those ill-inspired affirmations of the partisans of the past who shut their eyes to the light of the future. While people are scorning or ignoring the work of progress, Science moves ahead.

For some years, interest was manifested in what was called electrolytical bleaching, but which was, in reality, but the production of decolorising hypochlorites or hypobromites, by aid of the electric current. We have made some advance since then, and it has been acknowledged that it is unwise to utilise only one component of the chlorides in solution, when it is possible to obtain the chlorine and the caustic separately. As a matter of fact, attempts are being made to bleach by means of hydrosulphites produced electrolytically, and it seems that a better chance of success lies in that direction for the bleaching of wool, silk, &c.

Just as electrolytical bleaching has been abandoned, so the purification of sewage by the use of hypochlorites produced electrolytically will have assuredly to be abandoned, as it only acts when in a strong condition or in large quantities.

The future of purification of sewage lies in the use

of chlorine, in the same way that the sterilisation of water is to be effected by means of ozone, which alone can destroy the micro-organisms which drinking water contains. Among the electro-chemical problems, those of the purification of sewage and of water for town supplies rank among the first, and whoever may have done anything towards solving or rendering the task easier, be it ever so little, is deserving of encouragement.

The production of artificial perfumes with the aid of the electric current has made very much headway during the last few years, but in this case the action of ozone is far preferable to that of electrolysis, as it acts more directly, and in a more simple and energetic manner than the usual oxidising agents which have afterwards to be eliminated.

It does not appear that much recourse has been had to electrolysis in sugar refineries in England, but in several other countries, especially Germany, installations have been erected which would go to prove that the yield in sugar increases and that when the current has been used the decoloration, the purification and crystallisation are effected in a better manner and more rapidly.

Without trespassing on the grounds of electro-therapeutics, it will be permissible to point out the numerous experiments in cataphoresis which have been made during the last few years and show that electrolysis facilitates the introduction of medicinal substances through the skin of the patient and so cause their diffusion throughout the body.

Shall we attribute to a similar action the process of tanning by electricity, which has been so much talked about, and which is still the subject of so much controversy?

Until Faraday's time, it was only thought possible to electrolyse aqueous solutions; it was he who proved that many substances, such as oxides, chlorides, &c., when solid are non-conductors of electricity, but when in a state of fusion become good conductors and are decomposed very readily. Yet, up to 1887, only a few isolated cases of electro-metallurgical experiments in the dry way had been made.

It is only 10 years since some works for the manufacture of aluminium were started, and this "metal of the future," as people were wont to call it, this "precious metal" which fetched £150 and even more per kilo, to-day hardly costs more than four shillings. There is no one who does not know that in America, England, France, and Switzerland, there are works, the motive power of which is supplied by powerful waterfalls, turning out tons of aluminium produced in large crucibles heated by means of intensely powerful electric currents. What would Bunsen and Sainte Claire-Deville have to say were they to see such masses of aluminium manufactured in this way; they, who were the first to obtain aluminium by electrolysing a molten mixture of chloride of aluminium and sodium in a small crucible, the current being furnished by two voltaic batteries?

Here we come to the electrolysis of fused salts for the production either of the alkali metals or those of the alkaline earths, of chlorine and caustic soda, or of phosphorus and other substances; but how are we to treat or even broach this matter of electrolysis in the dry way, or that of electric furnaces, to which we owe the reduction of oxides, the production of carborundum and carbides, one of which, carbide of calcium, furnishes us with acetylene? It may be said that electrolysis by the dry way dates further back than electrolysis by the wet process, but it has yet to surmount many obstacles before becoming industrial. It offers such great advantages that if the difficulties are overcome it certainly is destined to bring about a revolution in electro-metallurgy.

The production of amalgams is another question which forms a very attractive subject, and which deserves attention in itself, more particularly from the point of view of the separation of the rare and precious metals.

It is a realisation of legitimate hopes and not of surprises which is in store for us for many years to come. The Niagara Falls and the numberless falls existing all over the world, will be rich in electro-chemical installations for working by the wet as well as by the dry process, and the time is perhaps not far distant when the waves of the sea will help to generate the current which the electrolytical and electric works may need.

We should have several other things to say, but time presses, and we can only allude to the electrolytical production of oxygen and hydrogen. The production of ozone by electrolysing solutions of sulphuric acid has been abandoned; but thanks to the adoption of alternating currents and of step-up transformers, it is possible to now produce it commercially, and in a continuous process. Does electrostatic ozone bring up the subject of electro-chemistry? or is it a point which might be contested, notwithstanding the fact that Houzeau has said that it appertains to the "electrolysation" of air? What is the correct theory as to the formation of ozone? Whatever it may be, we shall not speak about its applications, and it will be sufficient to state that 25 years ago there existed only excessively small apparatus for producing ozone, whose yield was of no consequence and of no use, whereas it is now possible to put up in very short time installations of 100 H.P. each, capable of producing each 240 kilos. of ozone per day of 24 hours, at the rate of £40 per ton, as if it were one of our usual commodities.

In a brief review of what has been done since the Electrical Review was started, we have been compelled to sketch out very slightly the progressive movement which has taken place, and to leave to conjecture the amount of work carried out, and of progress realised. We have not pointed out everything, and we have hardly mentioned any names; nothing has been described, and we have not even given a list of all that has been accomplished. In perusing these columns, the reader may fill up many blanks; names and things will be recalled which we have had to omit for want of space, but he will see from a better standpoint and in a better manner, what ground has been traversed during these 25 years, and the panorama of all the changes which have been brought about in art, science, chemistry, metallurgy, and many other industries by the application of this electrolysis, which for so many years was considered as being sterile, the laws of which were made known to us by Faraday, and the fruitfulness of which is now so great indeed.

The gold industry is already, and before long will be still more, indebted for its development to electrolysis, and it is with it that we shall finish. For more than a quarter of a century the aid of electricity has been sought for extracting gold from its ores. Numberless electrolytical processes, with and without use of quicksilver, have been devised. They have nearly all disappeared, one after another, or at least they have not been adopted in large installations, like those in the Transvaal.

The art of silvering and gilding is due to the use of cyanide in the electrolytic cell; the electro-deposition of gold, as it is carried out in the Transvaal, and as it will be very soon done in the United States, Mexico, the Australian Colonies and British Columbia, is due to the use of cyanide of potassium in an aqueous solution as a solvent of gold from its ores.

Twenty-five years ago the extraction of gold from its ores was effected on a small scale by the chlorination or the amalgamation process; electricity was not, and could not be applied anywhere. But, at the present time, tailings are treated in tanks, having a capacity of from 100 to 300 tons, and slimes in vats capable of holding as much as 1,000 tons. There is not a reader of the Electrical Review who is unaware of the fact that enormous quantities of gold cyanide solutions are daily treated by electrolysis which are poor in cyanide and poor in gold. To give an idea of what these electrolytic installations in the mining districts are like, we will content ourselves by saying that there lies before us a diagram of one of these, the anodes of which represent a total surface of 60,000 square feet.

Those only who have devoted all their attention to the study of the laws of the deposition of metals by means of the electric current, can form any idea of the difficulties and of the credit there is in electrolysing a solution circulating at the rate of 1,000 gallons per hour, which contains but a few pennyweights of gold when it enters the first tank, and which contains but a few grains when leaving the the last one. There is enough here to puzzle all the learned professors and all the authors of treatises which teach you the best way to deposit gold *secundum artem;* and we must consider this colossal application of the electro-deposition of gold which, most certainly, will be adopted for winning other metals as one of the most remarkable facts, and perhaps the

most important advance which can be vindicated among the conquests and the triumphs achieved by electrolysis during the last 25 years.

THE STEAM ENGINE.

By J. S. RAWORTH, M.Inst.C.E.

Man is not by nature an inventor. After Adam had discovered Eve, he and his descendants rested on their laurels for a few thousand years during which it is not clear that they invented any utilitarian devices beyond such things as the arrow and the bow, the millstone and the tallow candle. Other thousands of years passed in which the ingenuity of man was principally occupied in devising apparatus for the extermination of his fellow creatures or for mechanically converting them to the true faith.

It is a trite saying that necessity is the mother of invention, but the fact remains that the human mind has been most prolific under conditions which have the appearance of being, or of having been the reverse of necessitous.

In Egypt and in the United States of America, nature did and does so much for man in providing him with abundance of food, more indeed than he could or can possibly consume, that it is difficult on the theory of "necessity" to account for the wonderful developments, in the first case, of ethics and monumental architecture and, in the second case, of utilitarian and labour saving devices.

Of course it is absurd to assume that anybody or anything has only *one* parent, although it may be a puzzle to find number two, as is instanced by the fact that although Luxury is the father of Invention, the World was content to exist for several thousands of years without attempting to do more than was necessary to identify the mother; that is a pity, because it left the world ignorant of the main spring of its possible improvement. The fact is, that invention requires money, or, what is the same thing, unemployed labour to turn it to account.

The immediate result of James Watt's invention of the modern steam engine (the greatest gift that the human family has ever received and appropriated almost without acknowledgement from the hands of its sons) was to make it possible for one man to do the work that had previously been performed by two, and if the spare man had been content with his surroundings, the steam engine would have done no more for England than the potato did for Ireland, but, happily, the spare man, like Oliver Twist, wanted more, and set himself to devise new expedients for turning his time into money, or in other words for improving his condition. Thus the steam engine and the machinery for the employment of its powers have advanced at a constantly increasing rate, until at the present time the supply is not equal to the demand, and we find steam engines, and tools for their manufacture, coming from America to England.

A quarter of a century is not a long time in the history of the world, but it forms a considerable percentage of the epoch during which the steam engine has been lifting man out of the mire, teaching him to use his head instead of his hands, and opening up for his benefit the inexhaustible wonders of the world's wealth.

It is a shameful fact that while the steam engine has been doing so much for man, man has been doing very little for the steam engine; so little, indeed, that he could scarcely have done less.

Comparing the steam engines of 1897 with those of 1872, we find that in the first place, their number has increased enormously, for instance, the number of our locomotives has doubled itself in the said period and is now about 20,000. The number of our marine engines has also increased in about the same rate, and their aggregate power is nearly three times greater than in 1872.

When, however, we leave mere numbers and turn to the consideration of quality we do not find much ground for boasting; progress has been slow and has shown itself principally in the development of mechanical details and in overcoming the practical difficulties arising out of increasing pressures and speeds.

It is doubtful whether we should have enjoyed even this amount of progress but for the great improvements in the manufacture of steel which have given us boilers that will stretch before they will burst, flues that will collapse without tearing and crankshafts that no amount of ill treatment will break. Consequently, although engines have not grown in size, they now develop more power in a given space, with less consumption of coal, and better still, with almost total immunity from breakdown.

In marine practice the period under review has been notable for the complete ascendency obtained by the vertical inverted engine over all its rivals, and the equally complete disappearance of those marvellous mechanical motions with which our fathers puzzled their brains and filled our historical picture books.

But we have not yet finished with complication; that which formerly flourished in the legs has now settled in the head, and modern ingenuity finds work in devising all manner of combinations of cylinders and valves. Seeing that we have gradually risen from one crank per engine to four and sometimes five, and from one engine per ship to two, and occasionally three, involving the use of say 12 or 15 cylinders, it will not be difficult to realise how the engine room has grown into a factory, and the engineer who used to sit on a three-legged stool with a pipe in his mouth and his hand on the stop valve, has developed into a well disciplined army of engineers whose business it is to act the part of nerves to those great elephants which do the work but cannot feel pain or ache. Ultimately, no doubt, we shall make engines with nerves as well as muscles, and the chief engineer will instantly know when any joint or bearing commences to heat or grind.

One cannot forget that the Willans engine commenced life as a marine engine, and although it is self-evident that conditions of space, displacement, and stability preclude the use of this form of engine for modern marine purposes; yet there are points about it, not dependent on its steam cycle, which ought to commend themselves to the attention of the marine constructor.

The enclosed crank chamber provides absolutely perfect lubrication without any supervision; perfectly cylindrical "cylinders," without valve boxes cast on them, give an economical consumption of steam, such as the various dodges of triple and quadruple expansion are powerless to emulate.

Everyone knows that the modern marine was supposed, on the strength of the "affidavit" of its parents, to be a most economical engine, until it was actually tested by Prof. Kennedy under the auspices of the Institution of Mechanical Engineers. We now know that it will not bear examination. Of course, it is easy to be wise after the event, but it must be obvious to anyone who has accurately tested engines for steam consumption, that the modern steam engine is not built on lines of steam economy. Short stroke, large ports, safe clearance, massive columns abstracting heat, and imperfect clothing, all spell waste. Hence it comes that the best modern mill engine with only two stages of expansion can easily beat the best marine engine using three or four stages, and much higher pressure, by 2 lbs. of steam per horse-power hour. The next 25 years will cure all this and we shall find the marine engineer turning his attention from mere power, and plenty of it, to cheap power. He will do this when he ceases to be quite so pleased with himself (as he is at the present moment), when tens of thousands of horse-power begin to pall on his palate, and when he stops to inquire why the compound mill engine so easily beats the triple marine.

Just now he has plenty of problems on his hands, for it must not be supposed that the doubling of ocean speeds has been accomplished by a stroke of the pen or by the mere lavish expenditure of money; on the contrary, it has taxed the wit and the courage of our leading marine engineers to the utmost; and as each knot of speed has been laboriously added to the record, a new devil has had to be exorcised before the constructor could sleep in peace with his ship at sea. The public enjoy the result, they eat the best of dinners in palaces which would have astonished Haroun al Raschid, and, as in the smoke room, they crack their jokes and play "poker" while the floating city ploughs the main, little think they of the mighty human effort both of arm and brain which is being unceasingly exerted to shove that ship along.

Turning to land engines of the stationary type we approach a subject of enormous importance but of very little popular interest. To the public a steam engine is a locomotive. The mill engine is out of sight, and though its tireless energy has relieved our charming spinsters of the necessity of spinning, and permitted them to turn their attention to bicycling and other good works, I have never yet heard of one of them who possessed so much of the grace of gratitude as to cause her to say daily, "God bless the steam engine."

It is neither on their lips nor in their heart, and if one speaks to them of their greatest benefactor, of the man who made woman, or at least the modern woman, not to mention the new woman, they will blandly ask whether he were not the composer of

How doth the little busy bee
Improve each shining hour?

Such is the lot of the engineer; he may open up new continents, he may clothe all the female subjects of Her Majesty in silk and satin, and feed them with tea from China, coffee from Mocha, and mutton from New Zealand, adorn them with Kimberley diamonds and Johannesburg gold, and after all these princely offerings, his sole reward is to be confounded with a nursery poet.

"Sic transit gloria mundi," as Julius Cæsar said when he saw the flying Scotchman thunder through Peterborough. The worst of it is, that an unappreciative world does not even reward its engineers with respectable grave stones. But to return. 25 years ago the Corliss engine was introduced into England; many inventors had tried to improve upon Watt, but it was left to G. H. Corliss to do it. He obtained a patent for his invention in the United States in the year 1849, and there can be no doubt that if Mr. Montgomery or Mr. Henry Edmunds had flourished in those days, England would not have had to wait some 20 years for a participation in the fruits of Corliss's genius.

During the 25 years covered by our survey, the record of progress in mill engines is simply a history of the Corliss engine. There are as many varieties as there are makers, but still they are all "Corliss," and if ever Lancashire should desire to spend some infinitesimal fraction of 1 per cent. of its wealth in honouring those who have contributed to its success, it ought to raise a statue to the memory of G. H. Corliss. It should be made of white marble and standing in front of the Town Hall, Manchester, bear this inscription: "When your boilers are equal to my engines, you will save the cost of this statue in soap."

The Corliss engine has conquered Lancashire and the rest of the world by its excellent governing; its economical features have (so to speak) been thrown in. The millowner adopted it because it enabled him to spin better yarn, and to weave better cloth; but he got more than this, namely, the highest known economy of steam consumption, and the lowest expenditure on maintenance. All these advantages arose out of the simple fact that the Corliss engine combined the possibility of perfect governing, with automatic expansion and independent exhaust and compression.

The educational effect of the Corliss engine was diluted in the early and middle periods of its history by the prevalent belief that it owed its economical results to its sharp cut-off and beautiful diagrams. This pleasing illusion has been dispelled by hard facts, and our Continental competitors have so well learned the lessons it has taught them, that they have produced a new engine, the higher development of the Corliss thereby beating the record by 15 to 20 per cent. "*The letter killeth, but the spirit giveth life.*"

During the latter part of the 25 years under review, a new factor has enormously influenced the development of the steam engine. In the year 1880 a demand arose for engines to drive dynamo electric machines, and the demand, in the first instance, did little more than expose the poverty of the land; there were, in fact, no suitable engines in existence; now there are many, but that is a detail. The main point is that the output of a dynamo can easily be read in units of energy and compared with the energy in the coal used by the engine. The economy obtainable by the judicious use of such comparisons is clearly shown in the case of the Cornish pumping engine.

Peter William Willans early took advantage of the dynamo as an instrument for helping in the investigation of the performance of steam engines, and the results of his investigations were that he not only gave us very economical engines, even in small sizes, but he also formulated the Willans law, which has proved of immense service to engineers all over the world.

Out of Willans's success has arisen the English school of high speed engineers, which our friends on the Continent and in America have so far failed to imitate; even when they make a Chinese copy of the Willans engine the result is melancholy, so of course they immediately put on an air of superiority and recommend us to buy their engines instead of wasting time on making our own.

The other leading English high speed engines are the "Universal" (Raworth's patent) and the Belliss. The "Universal," in one sense, marks an epoch, for it has proved on a large scale, and in sizes from 25 to 500 H.P., that Corliss valves, positively driven, will work well at speeds from 275 to 500 revolutions per minute, and that, under these conditions, diagrams from a 6-inch stroke engine vary only very slightly from those of a true Corliss engine with 60-inch stroke and 60 revolutions.

All engineers, whether they belong to the high speed or to the low speed school, are now turning their attention to superheated steam—it is merely the revival of an old idea—some think it is an exploded idea; nevertheless, it is achieving wonderful results, and turning the wisdom of the wise into foolishness.

A superheater fits so neatly into a Babcock boiler without increasing its external dimensions, that one is inclined to believe Mr. Babcock had this development in view when he made his designs.

In Germany, superheating has been carried as high as 350° C. by Mr. Wilhelm Schmidt, of Aschersleben, and by these means, and others, he has been able to obtain 1 H.P. hour with 4·4 kilogrammes of steam. The other means referred to consist of an improved form of economiser, and an engine with a receiver of variable capacity. The effect of this variable receiver is to raise the pressure therein to meet the exhaust (auspuf) from the high pressure cylinder. Probably a considerable portion of the economy realised is due to this peculiarity, which is also shared by the Universal engine.

This short summary of the last 25 years of the life of the "steam engine" would not be complete without some note of the fact that knowledge is at this moment a long way ahead of practice. We know in what directions to look for improvement, we have Willans's experiments to guide us; moreover, in other directions we have living examples of Continental energy as compared with our lethargy; but the Britisher is not naturally lethargic, give him equal chances and he will win with certainty. How comes it then that other nations are now leading the way in steam practice? There are two reasons. In the first place our coal is too cheap, and we burn it as though it would last for ever; and in the second place, our system of tendering to specification takes away the last shred of inducement to the manufacturer to be or to do better than his competitors, and if he does better his details will be included in the next specification.

Our only hope of solid improvement lies in a reform of our procedure, or in the establishment of an engine building firm on so broad a basis that it may set procedure at defiance, and make engines of which their trade mark shall be their sufficient and only specification.

TWENTY-FIVE YEARS' PROGRESS IN ELECTRO-THERAPEUTICS.

By W. S. HEDLEY, M.D.

The history of Electro-Therapeutics is in a certain sense the history of Electricity. As the latter science has advanced there have always been physicians eager to follow in its footsteps, and anxious to turn it to account. But they have worked under difficulties. During the last quarter of a century, as in all former periods of its progress, medical electricity has been discredited by the pretensions of unqualified persons, by the prejudices of enemies, by the intemperate advocacy of friends; and, not least, by the crude electrical methods of

practitioners "duly qualified"—in everything but to handle an electric current. Through weal and through woe there has always been available a strong and willing ally in the Journal whose Silver Jubilee the present article is written to commemorate. Its editors have fully realised the fact that in electro-therapeutic work the physical problem must always underlie the biological one, and those who study these relationships have always found light and leading in its pages. Neither is it forgotten, and to-day it may be freshly remembered how, not long ago, alone and single handed the Electrical Review grappled with and strangled a mighty fraud. Those who know the story best are aware that it was not until after prolonged litigation, and vast expense, that this huge electro-medical imposture was finally laid low.

Before dealing with electro-therapeutics in the stricter sense of the term, it will clear the ground to refer to one or two closely cognate subjects:—In surgery the use of electricity has never secured, nor indeed deserved, any very prominent position; and its usefulness is still further minimised by the universal adoption of antiseptics. It was at one time hoped that in electrolysis would be found a method of dealing surgically with aneurism and with calculus. This hope has been realised only to a slight extent in the former case, and not at all in the latter. A considerable measure of success has attended a method recently introduced by Apostoli for the treatment of fibroid tumours, but it has never been extensively employed and seldom even fairly tried in this country. Electrolysis lends itself to the requirements of minor surgery in many well known ways, which cannot be entered into here. It is scarcely too much to say that electrolysis ought to take the place of all other caustics, and the electric cautery of all other cauteries, where public supply currents are available. For lighting small exploring lamps, accumulators and modern currents are a great stride forward. Electric illumination has made it possible to explore the interior of the bladder (electric cystoscopy) and to trans-illuminate the stomach by introducing into its interior a small lamp. Surgery owes something to electricity for the electric probe. The idea of using electricity for the detection of bullets embedded in the tissues seems to have originated with Professor Favre of Marseilles in 1862. But electrical exploration has not always proved a success. In the case of President Garfield an attempt was made to localise the bullet by means of the induction balance; but this attempt was not successful owing, it is stated, to the unsuspected presence of some metallic substance about the bed. In the case of Garibaldi it was not an electric but a porcelain probe which eventually decided the difference of opinion between the English and the French surgeon (Nélaton) in favour of the latter. The bullet was found to lie between the tarsal bones and was successfully extracted. It was De Wilde, a civil engineer, who (1872) first proposed the use of the electric bell as a signal of the presence of a metallic body in the tissues. An improvement on this is the telephone probe lately brought to the notice of the present writer by Mr. Mackenzie Davidson.* Its action depends on the difference of potential between two different metals, and upon the delicacy with which the telephone will disclose an electric current so engendered. A thin sheet of pure silver is placed upon any part of the body, and attached, by means of wire having a telephone in circuit, to a silver probe or heavily-plated exploring needle. If the probe be inserted into the tissues the telephone is silent because there is no difference of potential that the telephone will register; but immediately a metallic body, other than silver, is touched, there is a fall of potential, a current is produced and the telephone indicates the fact. Used to verify the localisation of foreign metallic bodies whose presence has been shown by the Röntgen Ray, this probe is a strikingly effective device.

Besides its surgical aspect in electrolysis, medical electricity has a *medicinal* aspect in cataphoresis. The process of passing drugs into the body through the uninjured skin by means of an electric current has undergone some development. It is stated* that in order to pass into the tissues the iodine of potassium idodide or the salicylic acid of sodium salicylate or of lithium salicylate, the *negative* pole ought to be in the aqueous solution of these salts. To transfer the strychnia of nitrate of strychnia, the atropine of sulphate of atropine, the quinine of hydrochlorate of quinine, the cocaine of hydrochlorate of cocaine, the lithium of lithium salicylate, the *positive* pole ought to be in the solution of the salt. But the law is not conclusively formulated yet, and the above may require modification.

A procedure which utilises both the electrolytic and cataphoretic actions of the current has recently been introduced by Dr. G. Gautier, and named "metallic electrolysis." Here the object is to secure not so much a destructive electrolytic effect on the tissues as the electrolytic dissolving of the electrode itself, and the diffusion of the newly formed salt into the tissues.†

Passing to electro-therapeutics proper, "the situation" 25 years ago may be briefly recalled:—The improved static machines of Holtz and of Töpler, had appeared some five or six years previously, but nevertheless frictional electricity had in England at least been almost entirely superseded by Faradism. The rotatory magneto electric machine was also disappearing. The induction coil might be that of Krüger and Hirschman of Berlin, actuated by Leclanchè cells; more probably the Faradic machine of Weiss, or the apparatus of Meyer and Meltzer, with zinc carbon elements excited by bichromate of potass and dilute sulphuric acid; and not strikingly different from some coils now in use. But such an instrument does not bear comparison with the induction coil in its most recent developments, with its wide range of secondary coils, its interrupter actuated by an independent current, and its rapidity capable of variation between 2,500 and 50,000 a minute. For a continuous current supply the Stöhrer battery was extensively used, with its sledge current selector and its current reverser; or the battery of Dr. Jerome Kidder might be preferred with its circular current selector, the latter an arrangement similar to the dial on the Meyer and Meltzer battery of that day. The Galvano-Faradic manufacturing company was already in the field with a good constant current battery. In England, that modification of the Daniell, known as the Becker-Muirhead, might be the chosen instrument, and in the hands of the more advanced specialist it would perhaps be furnished with a double current selector, a commutator, a metal rheostat, and even with a tangent galvanometer. But the latter would be a rarity, a novelty, and by no means considered a necessity. To-day "the combined battery" with its milliampère meter registering from one-tenth of a milliampère, to perhaps half an ampère, its induction coil, its double current collector, its current combiner and current reverser, and its cleanly and compact dry cells, is in the hands of every one who has any pretensions to the therapeutic employment of electricity. Even 25 years ago one instrument maker (Mayer & Meltzer) conceived the happy thought of combining a continuous current battery and an induction coil in the same box; but he seems to have been in advance of his time. It was objected that such an arrangement might prove inconvenient, for if either instrument went wrong the practitioner for the moment would be bereft of both currents. Now if it be remembered that for purposes of electro-diagnosis both forms of current are absolutely necessary, this objection becomes a very significant fact. But "Reaction of Degeneration" was not then a familiar word. Although his researches on the subject had commenced in 1865, Erb's improved methods for the quantitative estimation of excitability had not then been

* The present writer is not aware to whom belongs the original suggestion.

* Fubini and Purini.

† *e.g.*, if a copper electrode be used the metal is oxidised and chlorine evolved from the decomposition of the tissues; this forms, with the copper, a secondary salt, the oxychloride of copper, which diffuses into and over the affected part. Obstinate post nasal catarrh, tonsillitis, nœvi, lupus, sinus, fistula, have been successfully treated in this way.

elaborated. It was not until 1873 that these appeared. And it was not until 1882 that the now historic researches of Waller and de Watteville on the excitability of the motor nerves in the living man were published in the *Philosophical Transactions*.* It was only a year before this (1881) that the conditions of unipolar electrical stimulation in physiology and therapeutics had for the first time been clearly stated in England by de Watteville ("Brain," 1881). It may be mentioned that at the same time the view that a therapeutic system could be based on the opposing anelectrotonic and catelectrotonic conditions, received its first blow; a blow that has proved to be a severe and lasting one.

An important outcome of the above researches was the introduction by de Watteville of a method of *galvanofaradisation*, the principle of which is that faradic excitation is applied to that part of a nerve which is in a state of increased excitability through the application of the negative pole of a continuous current. (Neurologische Centralblatt, June, 1882.)

Reverting to 1872, it is evident that electro-therapeutics was then steadily advancing on sound lines. The instrumentation was an astonishing advance upon the battery of Daniell's elements, which Remak (1855) was obliged to "take to pieces and clean daily." The introduction of the rheostat, of the commutator, of the current selector, of the galvanometer, mark the dawn of a period of instrumental precision. This dawn may be said to have broadened into day when, in 1878, exact measurement in electro-therapeutics became possible by means of a definite practical unit. The history of the era thus commenced is largely the history of the milliampére. It is curious to read how such "history is made." Anyone who turns to the last edition of "Electrotherapie," by Ziemssen, would be led to believe that the commonly accepted medical unit was not only advocated but invented by that author himself, at the International Congress of Electricians, held at Paris, in 1881. D'Arsonval (Archives de Physiologie, 1889, p. 246) is more explicit: "J'ai réussi à faire adopter les unités C. G. S. aux électriciens des différents pays." Last, not least, comes an American confrère who naïvely (*New York Medical Journal*, January, 1889) ascribes the discovery of the milliampère to—of all men in the world—a late well-known gynæcologist, Sir Spencer Wells. Now the true history of the milliampère is as follows: Mr. Preece gave a lecture on the 28th of November, 1877, in which he suggested this sub-division of the original unit as a convenient one for measuring weak currents. At this time Dr. de Watteville was engaged on a series of original researches on resistance, current, strength, &c., from a medical point of view, and it at once struck him that the only way to make electro-therapeutists adopt absolute measurements was to introduce a convenient expression for a convenient unit; and this is what he succeeded in doing. From the day that the word "milliweber" struck on his ear he felt the want had been supplied, and began what eventually proved to be a successful crusade in favour of the new faith. Edelmann, in 1872, appears to have been the first to graduate galvanometers according to a rational and practical system, viz., in sub-divisions indicating the amount of chemical work done by the current. But it is Gaiffe in 1873 who first thought of the British Association unit, the "Weber," as applicable to medical measurements, and sub-divided his instruments in $\frac{1}{10,000}$ parts of that unit. Both these distinguished makers therefore deserve the highest credit for the new era they inaugurated. De Watteville's part in the matter was to suggest (under the circumstances above related), the adoption of the milliweber as graduation unit for medical galvanometers. This suggestion appeared in his "Medical Electricity," first edition, 1878, p. 6. A short summary of his views was published in the "Centralblatt für Nervenheilkunde," 1879, p. 530. Thereupon arose a sharp but friendly controversy between Dr. Remak, Dr. Bernhardt, and Dr. de Watteville, and as a result the latter was gratified to find that his suggestion had so far recommended itself to German electro-therapeutists and instrument makers alike that instruments graduated according to the new unit became the recognised measuring apparatus among the advanced section of the speciality. In the meantime, owing to the personal influence of de Watteville, Gaiffe in Paris, and several makers in London, had been graduating their instruments on the same principle. From this hasty historical sketch it will be evident who is the real "inventor" of the milliampère—Suum cuique! That the medical section of the Congress of Electricians in 1881 assisted the general acceptation of the milliampère is probably true, but to talk of their having had any initiative in the matter is ludicrously wide of the mark. The only original part of their work seems to have been the attempt to induce electro-therapeutists to accept as the Faradic unit the current strength expressed in terms of the scale of a certain coil, driven by a certain Daniell cell in use in the physiological laboratory of Berlin. This suggestion is seldom heard of now, and for good reasons.

From the advent of the milliampère onwards, progress has been characterised by a growing attention to electro-physics as the only solid basis of electro-therapeutics. It is more than ever recognised that the therapeutic effects of electricity depend upon the modality in which it is employed—on the physical character of the current. Further, that chemical and electrical processes are inseparable from those called "vital"; that electro-motive force is very commonly the outcome of physiological action; that there is a domain of "physical biology" or "biological physics" where electrical and medical science find themselves on common ground. Further evidences of progress appear in the more formal recognition of electro-therapeutics by the chief Metropolitan hospitals, and its endowment by the State in France; in the development of a special literature, and in the formation of such societies as the American Electro-therapeutic Association, and the Société Francaise d'Electrothérapie. Another era not long entered on is now in progress—the era of modern currents. The three conventional forms of electricity hitherto used in medicine, the "Galvanic," the "Faradic," and the "Static," are now supplemented and to some extent supplanted by electricity in new modalities. Taking advantage of the public supply currents that pass his door, the medical man finds himself in possession of undreamed sources of electrical supply, of unlimited usefulness and novel power. From the lead of a 16 candle lamp he helps himself to an ever-ready supply of electrical energy, either of a continuous or of an alternating kind. The former furnishes a current which will do for him all that the uniform flow of the galvanic cell can accomplish.* Passing the same current through a coil he obtains that dissymmetrical alternating current universally familiar as the current of the medical induction apparatus. Still availing himself of the same supply he heats his cautery, lights an exploring lamp or charges his accumulators, or passing the current through a motor, he drives his static machine or actuates his therapeutic alternator. The latter can in its turn be arranged to supply a current having all the smoothness and other qualities of that known as sinusoidal, with its rapidity, its electro-motive force, and even the shape of its electro-motive force curve under absolute control. If the current that is supplied in the street mains be an alternating one, he passes it through a transformer to apply it to the body, to electrolise his water bath, or to heat his cautery. The therapeutic usefulness of such a current is fully proved. That form of oscillatory current known as the "static induced,"† offers a most efficient method of producing powerful and painless muscular

* The alterations in the excitability of sensory nerves formed the subject of a communication by the same authors in October of the same year.

* By placing the patient in a shunt circuit—"a sliding shunt"—pain is abolished and safety secured, inasmuch as only that amount of electro-motive force is used which is absolutely necessary for the purpose in hand.

† Introduced by Dr. Morton, of New York.

contraction. It is the product of the static machine with condensers.*

Still more recently, the physician turns his attention to currents of great frequency and high potential, which open up new fields of physiological research, and endless therapeutic possibilities. For medical use they are generally obtained by means of the oscillatory Leyden jar discharge traversing a solenoid. Such currents may carry energy enough to incandesce 5-candle lamps, and if, at the same time, the human body be included in the circuit, there is hardly a perceptible diminution in the brightness of the glow; and, notwithstanding the tremendous amount of energy passing, there is scarcely a consciousness of its passage.† The physiological effects of such currents are stated‡ to be as follows: (1) analgesia at the point of entry and exit of the current; (2) a fall of arterial tension; (3) increased action of the skin; (4) increase in the "respiratory combustions"; (5) the virulence of blue pus is attenuated, and after about half-an-hour's application the bacillus dies. More recently, the same experimenter has addressed himself to "the soluble products of the microbe," the toxines. It is clearly shown by experiment on the living animal that an active diphtheritic toxine, through which such currents are passed, loses its toxicity. A result, perhaps, due to the molecular shaking to which the culture is subjected by the passage of a current of such high frequency of alternation.§

In a communication made to the Academy of Sciences, Paris, August, 1897, it was claimed for this current: (1) that it facilitates the elimination of waste products by the kidney; (2) it increases the activity of the organic combustions; (3) it tends to bring about a return to the normal ratio between uric acid and urea. When well supported, its effect in suitable cases is to improve the general condition, nutrition, and "tone" of the body, to restore appetite, sleep, and digestion, to induce an increasing energy and capacity for work. It has given negative results in neurasthenia, hysteria, and neuritis, but has proved useful in chronic rheumatism, "goutiness," obesity, asthma, anæmia, and diabetes. It is essentially the current that acts on the nutritive processes and on cell life.

How does it come to pass that such an amount of energy can harmlessly traverse the tissues? It has been suggested that these currents do not really penetrate the organism. It is known that rapid oscillatory currents do not flow uniformly through the section of a conductor. They tend to keep on the surface. Applying this fact to the lighting of the lamp as above described, it has been suggested by Mr. Campbell Swinton that the effect is to increase its resistance since only a section of the filament acts as a conductor. Now there is an abundance of electro-motive force available to overcome the resistance, and in overcoming it there must necessarily be a large expenditure of watts. This it is that lights the lamp. But it is contended that in the case of the living body the action on the vasomotor centres proves penetration. Further, that limitation to the surface is true only of *metallic* conductors. Penetration is deeper in proportion as the specific resistance of the conductor is greater. The formula being that penetration is directly as the square root of the specific resistance and inversely as the square root of the frequency. If this calculation be applied to the case of a cylindrical conductor having the same resistance and dimensions as the body, it will be seen that the diffusion is sensibly uniform. Further, that the latter fact may be directly verified by a cylinder of salt water (7 to 1,000), of the resistance of the body. It will be found that the current in this liquid cylinder does not vary $\frac{1}{100}$ of a degree between the centre and periphery.

It therefore may be stated of the currents in question that their physiological action is proved, that their therapeutic effect is within measurable distance of demonstration, and that the "mechanism" of their action is as yet unknown.

Painlessness seems to be the great characteristic of all high frequency work. It is to be observed* that rapid pure electric alternation produces no excitatory action on the neuro-muscular apparatus, but seems to exert merely a paralysing or fatiguing influence—what has been called a "throttling" effect on the passage of another stimulus. It is suggested by d'Arsonval that the absence of sensory effect is simply a question of frequency. The sensory and motor nerves are so organised as to respond only to a certain rapidity of vibration. It is so with the optic nerve, which does not take cognisance of vibrations below 497 billions a second (red), and above 728 billions (violet). According to this view each nerve, whether a special sense nerve, or a motor, or a sensory, or muscular, or vascular nerve, would respond only to a stimulus of a certain special frequency of vibration.

The use of such currents seems to broaden the field of electro-therapeutics. L'Electrisation localisée, the watch-word of Duchenne, now covers only half the ground. The great feature of modern practice is no longer to limit itself to strictly local applications, but equally to resort to such procedures of general electrisation, as have a demonstrable influence on the nutritive processes and on cell life.

Röntgen Rays in Surgical and Medical Work.

The public career of the X ray does not yet count its quarter century even in months, but an astonishing progress has been made. It may be true to say that little more is known now of its real nature than when, in December, 1895, Prof. Roentgen first announced his discovery; and that of all the "views" yet put forth, not one has so far received direct experimental proof. But, in the meantime, methods have been perfected, and surgery and medicine have not been slow to turn them to account. There is evidence of this in comparing the clear, well-defined pictures of articulations, organs, and cavities of the body produced to-day with the "fuzzy" shadows of the hand that less than two years ago astonished the world. Aneurism, calcareous deposit in the walls of the blood-vessels, cavities in the lung, effusions into the pleura, the size and position of the heart, the action of the diaphragm, even the paroxysm of asthma have (more or less darkly, it is true) all been disclosed. But it is in surgery that "the new diagnosis" has been of the greatest service. In dislocation and fracture it is now almost routine practice in the first instance to obtain a "Röntgen photograph" before attempting reduction and fixation; and afterwards to verify by the same means the accuracy of the coaptation. It is true that in the case of foreign bodies embedded in the tissues, although their presence has been clearly shown, the operation for their removal has not always been successful. In point of fact, it has not always been sufficiently realised that such a photograph is the shadow of objects on one plane that may, in reality, be situated on several planes. The *presence* of an object is shown, but no clear idea is obtained (1) of its size and position, nor (2) of the form of its surfaces and the relative superposition of its planes. A method of localisation has now been worked out,† which accom-

* The rods between the two Leyden jars being removed the inner coatings are connected with the discharging rods, the latter being separated by a small spark gap. If now a conducting cord attached to the outer coating of each Leyden jar be held in each hand, it is evident that such an arrangement gives two circuits; one, "the primary," includes the discharging rods, the spark gap, and the inner casing of the jars; in the other, "the secondary or induced," there is the patient's body, the conducting cords, and the outer coating of the Leyden jars.

† To measure intensity, d'Arsonval uses a modification of Cardew's galvanometer.

‡ Communication made to the National Society of Physics, 1897.

§ The foregoing points with reference to high frequency currents are from a communication made to the Medical Society of the London Hospital and afterwards published in the *Lancet*.

* Lodge and Gotch.

† By Mr. Mackenzie Davidson, and the present writer. The procedure as described by them in the *Lancet* is as follows:—Two wires at right angles to each other are placed upon the photographic plate, film, or paper. The Crookes tube is then placed with its anode at a measured distance from the plate and exactly perpendicularly to where the wires cross. The tube is fixed in a holder which slides in one plane. Further, one of the cross wires must be in exactly the same plane as that in which the tube is to be displaced. The wires being painted over with some pigment, the part to be photographed is placed on the plate and carries with it a mark of the cross wires. The tube is then displaced to a measured

plishes the first of these, and the stereoscope effects the second. The surgeon is thus supplied with all the information he can desire. By a single needle puncture, the localisation thus arrived at can be verified by means of the telephone probe. Although to a less extent than surgery and medicine, anatomy, physiology and pathology have also profited, and there is a possibility that the X ray may eventually prove useful even in therapeutics. But in the latter direction there is a danger signal in view that must not be overlooked. Instances are recorded where an erythema of the skin, and even an inflammation going on to suppuration, has followed exposure to the action of the focus tube. In such cases days and even weeks have sometimes elapsed before any effect became apparent, but at the end of that time an ulcer has formed, very painful in character and slow to heal. The "mechanism" of this injury is as yet an open question. But there are expedients for avoiding it,* and as exposures shorten and the extreme proximity of the tube to the tissues is no longer necessary, it may be expected that such cases will gradually cease to be heard of. It is certain that a depilatory action can be produced by the X ray, but how far such an effect is permanent, and how far it is produced at the expense of the vitality of the other structures of the skin, yet remains to be decided. Lastly, it seems fairly well established that in submitting cultures to the action of the rays the virulence of the pathogenic organism is not diminished; and although such a claim has been made, there seems to be no sufficient experimental proof that the process of exposure makes living tissue more resistant to the influence of a toxine.

distance to one side of the perpendicular and an exposure given, then to a corresponding point on the other side of the perpendicular and another similar exposure given. The resulting negative shows double images from the two different points of view. A further precaution is necessary—viz., to mark one quadrant of the plate and the corresponding quadrant on the patient's skin. The negative having been developed, fixed, and slightly washed, is at once placed on a horizontal stage illuminated from below by a suitable reflector (an arrangement similar to a re-toucher's desk). The negative may be placed with the gelatin surface upwards, or downwards if the glass is not too thick. In the case of celluloid films it is most convenient to place them downwards. The negative is adjusted so that a perpendicular dropped from a notch in a horizontal scale falls upon the point where the shadows of the wires cross. On each side of it another notch is made at the exact distance and height that the anode of the Crookes tube occupied in the two exposures. A fine silk thread is then passed through each lateral notch, and a small lead counterweight is attached to one end of each thread, while the other is passed through the eye of a fine needle. The needle is weighted with lead so that its eye lies flat on the surface of the negative. In short, these two silk threads represent the path of the X rays, so that if each needle be carefully placed upon a corresponding point in each shadow, it follows that the point where these threads cross marks the position occupied by the corresponding part of the actual object. Further, its distance can be measured perpendicularly from three planes—from the horizontal which gives its depth, and from the two planes represented by the shadows of the cross wires. By measuring any other desired corresponding points the precise size, position, and direction of the object can be determined, and remembering that the cross wires have left their mark on the patient's skin, the surgeon can at once obtain all the information he can possibly desire.

* *e.g.*, The interposition of an aluminium plate, or wrapping the vacuum tube in black cloth.

TWENTY-FIVE YEARS' PROGRESS IN BOILER MAKING.

By W. H. BOOTH.

The progress in boiler making during the past quarter of a century has been very great, but it has been almost wholly in the direction of workmanship, and not in principles; unless, indeed, we accept as a principle the water tube system, which has come into extensive use during the period named. We do not know how far many of our readers will be pleased to consider that the growth of this system is properly to be included under the head of progress in the sense of improvement. Twenty-five years ago the ruling pressure could not, we think, be fairly stated as above 50 pounds per square inch. To-day, pressures rule at 150 pounds, and occasionally we find 200 pounds, or even the higher pressure of 250 pounds. The advance has been at least 100 pounds, or at the rate of 4 pounds annually; but progress in this, as in other things, has not been along a flowing curve, but in steps, or gradually, to use this word in its strict meaning, as will be obvious when we come to consider how advanced pressures have become possible. To travel back beyond the strict limit of our title, or say to the period between 1830 and 1840, we find from an old letter written by a Lancashire steam user that the first boilers he employed were of a simple cylindrical type, and from below the water level a pipe was led off, and carried up to a height of 15 feet above the floor level. These water pipes were open topped, and if the pressure of steam in the boiler became unduly high, water would pour out of these pipes, and give notice of the fact. It is, therefore, clear that steam pressures in 1830–40 were limited to about 7 pounds. A few of these old boilers or their contemporaries are still to be seen doing duty as water tanks, and they are seen to be composed of very many short plates, about 2 feet by 1 foot, single hand rivetted. From that time to the year 1872, progress in boiler making was steady. The plates provided by the ironmills became longer and wider; double rivetting was introduced, which raised the strength of the joints from 56 to 70 per cent. of the solid plate, and public attention became directed to the subject. The Manchester Steam Users' Association was founded in the year 1854, and by the commencement of the past 25 years, pressures had gone up from 7 pounds to 50 pounds.

References to professional papers show that in the year 1876 high pressure meant 75 pounds, and the shell of a boiler 7 feet diameter was made up of plates about 3 feet wide, and not more than three plates were specified to be used in the circle. Boiler plates were thus rolled about 7½ feet by 3½ feet. The material of the shell was as a rule iron, but steel plates were frequently used in the furnace crowns.

Average progress in anything is not the measure of the high-water mark, and it would be wrong to make no reference to the pioneer work of the late Daniel Adamson, who was wont to say that he would have boiler making raised to as high a pitch as engine making. It was he who introduced the flanged seam for flue tubes and furnaces and employed it so far back as 1851, and used it in 1856 in some boilers made to work at 100 pounds which were still at work in 1876. But Adamson was the pioneer and only dragged the trade behind him at several years' interval. To him is due the flanged seam, the drilling of rivet holes in place, and the use of steel for all parts of a boiler. Punching was practised even in 1876, though pressures of 100 pounds were occasionally employed. Boiler shells could be made to stand a given pressure with comparative certainty, but the strength of the tubes was uncertain. A lap-rivetted tube was not circular and this was its weakness, and it was early found that the strength to resist collapse was inversely as the length of tube, and that stiffening rings increased the strength almost in proportion to the number of sections into which they divided the length. Until the comparatively recent introduction of corrugated and ribbed tubes there has been nothing to touch the efficiency of the Adamson seam. It made possible hitherto impossible pressures, and it threw back upon the shell of the boiler the onus of showing the way to possible higher pressures. The furnace in fact became stronger than the shell and thus there became necessary the drilling in place of shells, the use of steel plates and the improvement of the rivetted joint. In this latter detail progress has been steady, so that now we find the butt joint with double cover strips and a third row of rivets spaced more widely apart in order that the reduction of strength of the plate may be only that due to the removal of the material for this widely spaced row of rivets. In 1883, we find a reference to the increasing use of steel for boiler plates and, at the same time, though many boilers were being made for 90 and 100 pounds pressure, this latter being adopted at certain new spinning mills in

Stockport and in Blackburn about that time for boilers of the largest size then made, we note the expression "for pressures so high as even 80 pounds" used in such a manner as to indicate that this pressure was still considered high, and speaking approximately 100 pounds was about as high as was deemed necessary to use for compound engines.

Not merely in the details of the shell and tubes but also in the staying do we find improvement. The attempt to hold flat-end plates rigidly in place had been given up at the commencement of our 25 years' review, and space was allowed for the movement demanded by the expansion, rise, and fall of the furnace tubes; but this space, once about 7 inches between the furnace end rivets and the lower rivets of the gusset stays has become 12 inches. Gusset stays, once attached to single angle irons by a bent up rivet are now held securely between two angles by properly closed rivets and to-day the steam boiler is as fine a piece of mechanical engineering as any engine. In 1895 the high-water mark was reached in the shape of a Lancashire boiler 30 feet long by 8 feet 10 inches diameter which was made by Messrs. Tinker, Shenton & Co., of Hyde, for a working pressure of 200 pounds. The shell of this boiler is of Siemens-Martin steel 1 inch thick and only one plate goes to each ring, there being but eight plates in the whole of the shell barrel. There are double-butt strips, the outer ones containing the six rows of rivets of the ordinary treble rivetting while the inner strips contain also a double spaced fourth row. Every hole in the boiler is drilled in its place, the large end plates are rolled in one piece, the rings of the furnace tubes are, as has been many years the practice, welded before being flanged and the plates of the shell are bent in a vertical set of rolls. The three roll horizontal benders are not now considered fit for good work for they cannot bend a plate to a true circle right up to the ends. The vertical roll machine does this.

With quadruple rivetting, it is claimed that the joint strength is nearly 90 per cent. of the solid plate. Once the strength of a given style of joint is known, and future similar joints can be relied upon for the percentage of strength once ascertained. It does not seem likely that welded shell seams will supersede the rivetted joint, unless welding can be proved capable of better results than say 95 per cent. of solid plate. The only serious improvement in view would therefore seem to be the rolling of the rings for a boiler in one solid jointless circle, exactly as tyres are now rolled. The objection to this is, perhaps, more one of carriage than of engineering; but if whole boilers can be carried, then surely can their separate parts, and the near future will certainly see the Lancashire boiler made of solid rolled plates. The immediate saving in weight would be about 12 per cent. on plate account alone, apart from the saving of the butt strips and rivets, a further 12 to 15 per cent. probably. It is not merely in size and material that boilers have been improved. Twenty-five years ago plate edge planing was not the practice; there was little discrimination exercised in rivetting. To-day, pressures on rivets are regulated to what is suitable for each size of rivet. Thus at the above-named works of Tinker, Shenton & Co., the pressure is regulated by using steam as the working agent drawn from a special boiler, in which a maximum pressure cannot be exceeded, because the safety valve of the boiler is weighted to the necessary pressure.

As boiler pressures have progressively become greater, there have never been wanting those who have forcibly stated that the limit of pressure had been reached for boilers of the shell type; yet to-day we find that the steam drum of the water tube boiler is exposed to greater stresses than the boiler shells which, 25 years ago, were declared to have reached their limit of endurance. The unvarying remedy of the reformers has been, throughout, the use of smaller vessels, and 24 years ago, we find recorded numerous explosions of "safety" water tube boilers, which gave to the water tube boiler its early bad repute. In spite of all prophetic denunciations, the shell boiler, either in its Lancashire or marine form, has steadily met all the demands made upon it. The flanged furnace tube settled the question for this, the once weak link in the chain, and was used for the furnaces of the 200 pounds boiler above described. Then came one by one, if not in the order named, the drilled rivet-hole, now set out by automatic dividing machinery, the mild and now thoroughly reliable steel plate, the plate edge planer, machine rivetting, improved rivet spacing, larger plates, better stays and better fittings and mountings in place of the once cast iron blocks. Then the abolition of the dome, and the use of the antipriming pipe have removed a great source of weakness, and to-day the shell boiler is ready to respond to the highest pressures employed. But it would not be fair to leave the water tube boiler out of notice. It also has improved, and is a very different affair from the "safety" boiler of 25 years ago. It has participated in the improved material and tools that have kept the shell boiler to the fore. It is not a little curious to note that while boiler making has advanced so much, comparatively little has been done to improve boiler using, unless we look upon the seating and placing of a boiler in better and dryer houses as such. Grates are practically identical with the grates of a century ago. Firing remains much the same and mechanical stoking has done comparatively little. Forced draught is being employed to increase the output of steam from a given boiler, but generally there is little to show in boiler practice beyond the making, and in this one department the advance has been very great. Electrical engineering has very much aided the advance by its demand for higher pressures. Before the era of the electric station there were few large concentrations of economical power outside the manufacturing districts, and there, care was always taken to secure water for condensing. This has not been always available for electrical stations and the tendency has been towards higher pressures which would reduce the proportional importance of condensing. But condensing is so really important that this very fact has given a fillip to such things as evaporative and air condensers, for use when water is not present in quantity.

One of the more recent developments of practice has been the self-contained marine boiler for stationary purposes, but we need not recapitulate the influences that have gone to improve the marine boiler as well as the older stationary forms of shell boilers, until to-day all shell boilers more closely resemble each other than they did before the growth in pressures put a stop to the internal flat surfaces once so common. To the eye of the present-day engineer the working pressure of the shell boiler has no limit in respect of the shell plates and furnaces unless it be that of temperature. As regards strengths no one doubts that any thickness of plate will be rolled that may be asked for. There is however some food for thought in regard to the temperatures of high pressure and the influence on the tensile and compressive resistances and qualities generally of shells and furnaces. In face of the past 25 years' experience it were, however, rash to predict a limit to future practice. The broad fact remains that the boiler of to-day is safer at its pressure of 150 or 200 pounds than its smaller predecessor was at 50 to 75 pounds when the last quarter of the century was ushered in. The introduction of the steam turbine is supposed to make for high pressure, yet we cannot blink the fact that the pressures already available are much too great for a steam turbine of the De Laval type to utilise, for a sufficient speed of rotation has not been secured to give to the vanes of the turbine a velocity anything near the half velocity of efflux of steam which theory points out to be necessary.

Reference has been made above to the convergence of the Lancashire and marine types of boiler. The growing similarity has been more perhaps on the part of the marine boiler which, from being once simply a boiler with no external flues, has in some instances been arranged with external flues, or what is in effect the same, has been enveloped in an outer casing serving the same purpose. Practically nothing has been done in the way of firing boilers by gas instead of by solid fuel. The use of a clear burning gas is not apparently conducive to

economy in the absence of special means for securing radiation effects. Neither has liquid fuel come into much use. Liquid fuel cannot come into prominence so long as the supply of oil is so small as it really is compared with the supply of coal. Solid fuel alone is commercially available and likely to remain so for steam purposes, and it is not a little strange that so little has been done in the way of improvement in stoking. To-day, as 25 years ago, there are poor stokers—there are skilful good stokers and there are skilful bad stokers who seem to come to the front when a patent has to be tested and it is necessary to stoke well or ill to suit certain desired ends. Stoking perhaps hardly comes under the head of boiler making, but it is noticeable that nothing in the past 25 years, or for the matter of that the past 75 years, has been effected in boiler making principles that has done anything towards a better utilisation of fuel. It is to be hoped that the idea of getting more from fuel by worrying half-consumed flaming gas among a lot of cooling surfaces has almost died out. Increase of pressure means increase of temperature, and future economy cannot be attempted without stage heating of the water and stage cooling of the gases. Hence the success of the economiser or flue feed heater. Water tube boilers are claimed to be as efficient without stage heating as shell boilers are with it. Common sense, apart from scientific fact, disproves this and the claim ought to be judiciously abandoned. In its initiation the water tube boiler was the outcome of the idea that boilers of large diameter could not be made safe, but we see the steam drums of the water tube boiler as much stressed by steam pressures to-day as were the shell boilers at the time the water tube boiler came forward. In fact, water tube boiler inventors could not foresee good mild steel, and did not realise the possibility of modern plant in boiler making, and they put on the market boilers made largely of cast iron, as though anything would do for a boiler if only small enough. The shell boiler, on the other hand, has grown to its present status, because its makers have acted on the principle that any size of boiler could be made for any pressure, if only well enough made of good enough material. In competition with English work the cast iron water tube boiler, as it came crude from America, has been much improved, and much of the cast iron eliminated. It seems clear, however, that the sentence passed on shell boilers years ago was "be strong or die." Under this stimulus the shell boiler now stands *facile princeps* in the estimation of all steam users and experienced engineers. We have seen the final limit of pressure so often laid down as being attained that we refrain even now from prophesying until we know, and we don't yet know that when steel reaches its limit of temperature, there may not be a fresh alloy of iron. Twenty-five years of past experience points simply to the raising of the limit, as it has seemed desirable. If anything will check further advance, we should think that the check will come rather from the diminished rate of increased economy, to be secured from further pressure.

Speaking generally, the 25 years passed in review may be said to have been ushered in with the conviction that the day of shell boilers was about to close. The cycle closes, and we are almost made to doubt whether shell boilers have even yet been fully evolved, so great has been the mechanical advance made in their construction, under the joint stimulus of rivalry and demand.

TRANSFORMERS.

By JAMES SWINBURNE.

It is my duty to trace the history of transformers during the last quarter of a century. The first part is difficult because transformers are not as old as the Electrical Review. In days of old there were induction coils, or Ruhmkorff coils, which were chiefly remarkable for their unscientific design, and the variations in spelling of their author's name. The theory of induction coils was very little understood, and was not, apparently a matter of much interest.

The history of the transformer really began nearly 20 years ago. At that date there was a great problem to be solved, known as the "sub-division of electric light." People made series dynamos and ran single arc lamps with only series coils on them, and they could not make out why they could not run several lamps off each machine, either in series or parallel. Jablochkoff about this time, before the invention of what is now known as the Jablochkoff candle, proposed to run a number of lamps of a peculiar kind in series, but as the extinction of one lamp (which the slightest acquaintance with the proposed lamp shows to be a highly probable occurrence) would put out all the rest on the circuit, he proposed to put each lamp on the secondary circuit of a little transformer, and to couple the primaries in series so that the primary circuit would not be broken by the extinction of one lamp. Of course Jablochkoff did not then understand the back electro-motive force of transformers; but on the other hand he most likely did not quite know how to make a transformer that would have much back electro-motive force, anyhow.

Then the Jablochkoff candle was invented, and made a great stir at the Paris Exhibition of 1881.

Jablochkoff had alternating machines with several circuits on each machine, generally eight, and about five lamps in series on each circuit. They were really double current or "diphase" machines, but were not used for driving motors, as far as I have ever heard.

The induction coil became a favourite theoretical method for getting power in the secondary without any back pressure in the primary, and figured a good deal in publications of that date; sometimes it played the less imposing role of providing series circuits without extinguishing all the lights when one went out. In 1881 Messrs. Deprez & Carpentier proposed to transmit power to a distance by means of two induction coils. A Ruhmkorff was to be used as a step-up transformer at the generating station, and as a step-down transformer at the receiving station. This was a crude idea, and is, I think, the first publication of the idea of the modern transformer.

In 1882, however, Gaulard & Gibbs came on the scene. They made up for want of technical knowledge by enthusiasm. They hoped to avoid back electro-motive force, or to reduce it considerably, but they really saw the great advantages to be got. It must be borne in mind that in 1882 dynamos were nearly always series wound. At the end of 1881 Messrs. Siemens Brothers had produced the shunt wound machine commercially, but most makers did not take it up for some time after that. Compound wound machines were not known, the idea of compound machines not being published till the end of 1882, while the machines themselves were not made until later still. It is very difficult to realise how little we knew in 1882. People were beginning to see trouble in running lamps in large numbers in parallel. I remember writing a letter to this journal about that time to point out the fabulous size the conductors would be in some cases of parallel distribution, which no one would think of now.

Gaulard & Gibbs produced open iron circuit transformers, and arranged them with their primaries in series, and their secondaries in parallel, and showed the system at work at the Aquarium, and lighted some of the Metropolitan Railway Stations, Gower Street and King's Cross, if I remember right. Their transformers were badly designed, but that was to be expected in those days.

It has since come to light that Mr. Bernstein applied for an American patent for the same system, but the Patent Office refused the grant on the ground that you could not possibly get "more current out of a machine than you put in."

Messrs. Gaulard & Gibbs were really the pioneers of transformer work, and most of us who are unfortunately beginning to realise that we belong to the old school of

electrical engineers, can remember Gaulard's enthusiasm on the subject in the old days of the "Dynamicables."

The fate of Gaulard & Gibbs' transformers was, that they were treated with ridicule. At first people said the system could not work; then, it must be absurdly inefficient; and then, it was old, and everybody knew about it long ago. Poor Gaulard eventually died under distressing circumstances, and the transformer system went out of repute.

For the next two or three years people were all at work on direct current machines, and distribution by direct currents with accumulators. It was not till about 1885 that the question of alternating transformers came up again. Messrs. Ganz showed a transformer in the Inventions' Exhibition, in 1885, and the idea took on. It then occurred to people that there was no reason why a transformer should not be very efficient indeed. The Ganz transformer had a closed iron circuit, and that opened new possibilities; and as the direct current seemed at that time to be rapidly approaching the limit of its tether as regards distribution, the alternating current made tremendous way.

The Westinghouse Co. in the States developed a transformer business at a phenomenal rate. In this country Ferranti took up the system, and put it in practice at the Grosvenor Gallery Station, which is now a part of the London Electric Supply Co.'s system. The closed circuit transformer has undergone very little improvement since 1885. It is proportioned better, and understood better, but that is all. It is the same thing, with only slight alterations in proportion.

By the time the transformer was practically thrashed out and in general use, it was time for the so-called theorists to tackle the subject. Everyone, from those who just knew how to differentiate the sine and cosine with respect to the angle, up to some of the ablest mathematicians of the day, seems to have turned himself loose on the subject. The victim was attacked from two sides; one section of the invading force made clock face diagrams, which were so absurdly wrong in scale that they gave no idea of what goes on in a transformer; and the others attacked it analytically, and wrote strings of equations. The transformers that were subjected to attack by analytical methods, generally had resistances R and r, and self inductions L and sometimes L', and even mutual induction M. They seldom had all these recommendations at once, and even now people will talk about the "self induction of the transformer." I remember as late as 1890 trying to explain to a pure theorist that the transformer designers did not work in that way, and that none of my assistants would know what the self induction of a transformer was. He said "it is a shocking state of things." So it was, I do not know even yet what the "self induction of a transformer" is, and I fear I never will know.

All these calculations, geometrical not to scale, and analytical with letters instead of numbers, have been almost absolute waste as far as information goes. They occupied a great deal of room in the technical papers, often involved very advanced mathematics, were generally considered very deep and learned by those who did not take the trouble to see what they were all about, and they must have been very expensive to print. The yearning for publishing elaborate calculations on insufficient or wrong data seems to be almost a disease. It is going on still. I remember writing an article showing that the magnetic current could not possibly vary harmonically, and showing how it could be inferred from the hysteresis curve, and shortly afterwards Ryan independently investigated the subject experimentally and showed that the magnetising current was always what was needed to magnetise the iron, having regard to its position in the cycle at that instant. This did not daunt the attacking force a bit, it only gave them more to work upon, for they seized upon Fourier's series and have revelled in it ever since. There are still papers and books coming out on the so-called theory of alternating currents, and multiple current work has given it a new lease of life lately. As far as I know, it has never had the least influence on the design or manufacture of any practical electrical apparatus. I do not mean that engineers do not make use of a certain amount of calculation involving harmonic currents and pressures, but that the elaborate and complicated calculations of theorists, with letters instead of figures, or diagrams not to scale, have been practically waste paper.

The broad view of a transformer as a core which at any instant has sensibly equal and opposite ampere turns in its two circuits is, I think, hardly yet fully grasped by all the theorists; it is essentially an engineer's view. The idea of the primary current being made up of an active component in step with the pressure, or on inductive load with the secondary current, and an exciting component depending on the hysteresis curve; the calculation of the Foucault currents in the iron cores; the change of hysteresis loss with age; the predetermination of inductive or magnetic leakage drop; and the relations of size to internal loss necessary for keeping down to given temperatures are all due to engineers who make transformers as opposed to the academical writers on alternating currents. We must gratefully acknowledge Lord Kelvin's work on the "anti-effective copper in coiled conductors," but then we all regard Lord Kelvin as a practical engineer, as well as a great many other things besides.

It may be assumed that I ought to mention something about the Hedgehog transformer; but I will say little, for it has played a far less important part in commercial work than on paper. The Hedgehog was talked about a great deal, but it was never sold much. At the date the Hedgehog was brought out, 1889, people had by no means realised the all-day loss in transformers, especially in transformers as then built. The transformers of those days had very high iron losses; and it had not occurred to engineers—still less to the clock face makers or analysts—that the full load efficiency of house transformers was of very little importance, but that the all-day efficiency was the really important quality. Even now, eight years later, the full load efficiency of transformers is constantly discussed, and the efficiency on all-day load hidden away in disgrace. The Hedgehog transformer was designed to have a much higher all-day efficiency than is possible with a closed circuit transformer. With iron of the same quality an open circuit transformer can be made to give a considerably higher all day efficiency. Though the iron loss is small, the exciting current is enormous, and this is the real drawback to the open circuit form. The attention directed to the low all-day efficiency of transformers, which was of course not forgotten by the partisans of direct currents, led engineers to design closed circuit transformers more carefully, and the disadvantage of the large idle current soon balanced the advantage of higher all-day efficiency, and the Hedgehog never came into general use. In addition to this, iron wire is so often heated and annealed that it is difficult to get it of such good quality as sheets, and by the time it is made up into the core of a Hedgehog it is very bad indeed. In some Hedgehogs tested by Dr. Fleming, the loss in iron was excessive. It was supposed that there was some loss due to uneven distribution of skin effect in the secondary, but that is absurd, as the skin effect is replaced in a transformer by uneven current density, and that only occurs at loads, and is cured by cabling, which is not effective in a single conductor.

The most recent, if not the only recent addition to our information is the increase of hysteresis in iron with age or use.

Multiple current transformers are really only single transformers stuck together, so that part of the iron may serve for more than one magnetic circuit, so they have no interesting history of their own.

I do not know if direct current or rotary transformers are supposed to come under this heading, or whether they will be treated by some other pen.

The direct current dynamotor has no separate history. This name, by the way, was once objected to by the Sub-editor of *Industries*, on the ground that it had a Greek beginning and a Latin ending. I declined to give him a name that was all in one language, as that would be a departure from electrical, or indeed scientific practice,

but I offered him as an alternative "vimkin," with a Latin head, and a Greek tail; he preferred "dynamotor."

The only history the dynamotor has had has been its use in what may be called "dodges." If it is wound with separate field magnets, they may be excited in all sorts of ways to give all sorts of results, convenient in particular circumstances. Combining dynamotors to give constant or rising pressure on the secondary, with falling primary pressure is about 10 years old now. Dynamotors may be used as adjuncts for topping off batteries in central stations, or for helping them to discharge at high pressures on full load in feeder stations. A dynamotor on the mains at an outlying point may have its primary machine shunt wound for constant speed, and its secondary armature in series with the mains; the secondary field magnets also being in series, the machine adds pressure to the system which is proportional to the current, and as the loss in the mains is also proportional to the current, this system preserves constant pressure at any desired point, which need not be at the dynamotor. Ward Leonard has proposed a dynamotor system for supplying tramway motors with desired current at varying pressures instead of at fixed pressures, so as to avoid the waste in resistances. In fact, whenever you want to do anything in the self regulating way in direct currents, the only question is "how shall I wind my dynamotor to do this?"

The dynamotor, with one element an alternating machine, is also old and obvious. It is possible, however, to make one armature do for both, if it is multipolar and goes fast enough. Messrs. Schuckert showed machines of this sort at the Frankfort Electrical Exhibition in 1891. They were low frequency machines with commutators, and several sets of slip rings, so that they could give or take direct currents, and single, double, or triple alternating currents. The armature was an ordinary direct current ring. It is possible, however, to make a comparatively small machine convert direct and alternating currents, and such machines were proposed for Woolwich in 1892. The armatures were to be wound with conductors suitable for carrying only the difference between the direct current and the instantaneous value of the alternating current at each position. This means quite a small armature, specially wound. But the idea was not put into practice because it was too experimental for important work where time was an object. The question of sparking in transforming direct and single alternating currents is serious in such a case, and there are other questions in connection with the pole pieces which would demand too much careful consideration.

It is not wise to try and make history backwards by looking forwards. The tendency seems to be towards substations, as might be expected, but the chief difficulty at present is to adapt the alternating current transformer system to electrical traction. There is no difficulty as regards triple or double currents, but the use of single current transformers awaits the single alternating current motor which will do the work now done by direct current machines.

THE PROGRESS OF ELECTRICITY ON RAILWAYS DURING THE PAST TWENTY-FIVE YEARS.

By W. LANGDON.

Although no one can doubt that in locomotion electricity is destined to find one of its chief fields of utility, it must be admitted that so far we have no very tangible sign of its superseding the "locomotive" of the present day in the disposal of that enormous traffic which now falls to the lot of our railway service. And yet it is not quite obvious why, if all had to be done anew, this should be. Naturally, electricity capable of handling this great traffic would have to be employed upon an entirely different basis to that which characterises the present propelling power. A unit or initial power, as with the "locomotive," there would be, but to work advantageously, the power, as a rule, would be distributed throughout the mass required to be moved. Each vehicle should have its own motor, to be brought into use to aid the initial power whether an independent vehicle, devoted to the traction of the train, or applied to other purposes as might be required. We may say that power is power, whether derived from steam or electricity; so it is. Steam is, however, a primitive power, whereas, electricity is derived. A loss must ensue between the prime mover and the applied mover. Is this to be compensated for by the many advantages the application of electrical energy would possess? The steam locomotive carries a large mass of dead weight—a weight which not only reacts upon itself but adds to the wear and tear of the line. As an economical steam producer it cannot compare with some of the present-day stationary engines employed for the generation of electricity. Its wear and tear must be considerably greater. In the distribution of electricity there would be a certain loss. How far the advantages which would otherwise attend the application of electric energy to the purpose would compensate for this loss plus that lost in the conversion of steam into electricity is a question which will no doubt, at no distant date, receive close and careful consideration. Take any one of our large railway systems, sum up the acreage of ground devoted to locomotive engine purposes—engine sheds, yards, workshops—compare it with that required supposing the system were worked by electrical agency. Consider the staff now employed and that which would be needed! These are all points worthy of attention. The time has not yet arrived, but it is undoubtedly approaching when the question will arise: Can electricity fulfil this duty, to what extent and to what advantage? Not probably in relation to established lines but in respect of independent feeders—feeders of a calibre something greater than a light railway, or a road tramway. There is in it the seed of a great future, but a seed which can hardly be said to have yet germinated, or, if so, it has yet to be cultivated and trained in its application to the purpose.

In casting our eye back upon the past, however, we feel that, whatever may be the part which electricity is destined to play in future, in locomotion as applied to the railway service of the Kingdom, it has not up to the present fulfilled any very active part. Such advancement as has arisen in electrical appliances must be looked for in other channels—channels which perhaps not of such magnitude, are yet equally important and involving large outlays. There is probably no more conservative institution in the world than a British railway. I will not say railways in all, for in America one of the institutions apparently ever ready to welcome innovations and test their advantages, is the railway institutions of that country. With British railways, established and equipped at great cost, carefully watched over and regulated by the State and administered by a staff of officers and men educated in a certain groove, economy and system both resist radical changes; yet for all this the progress which has been made in the advancement of electrical appliances has been of a stable character, and in point of capital outlay will give place to few, if any, of the several fields in which electricity has found a useful footing. British railways may claim to have been the cradle in which the telegraph was rocked. Rejected by the Government of the day, railways became its foster-mother. Impossible, no doubt, it would have been for telegraphy to have long lain dormant. Its vast commercial utility must sooner or later have secured it the position it to-day occupies, but had the railway interest adopted the view of the Government, its early advancement must have received a serious check. As railways became its nursing ground, so on railways it has flourished, until we now find every main line blocked with poles and wires, and there can be no question that want of space, or the great value of the space which even a line of telegraph occupies, alone prevents a still greater aggregation.

In 1872, the total mileage of double lines of railway in the Kingdom was approximately 7,000, about half of which was worked under the Block; and some 6,000 miles of single line, the greater portion of which by far

was worked by the "Train Staff." The Board of Trade returns show that at the conclusion of 1896, this mileage had increased—in respect of double lines to 11,589 miles, and in respect of single lines to 9,688; the respective details for each country being as under :—

	England and Wales.	Scotland.	Ireland.	Total.
Double Lines ..	9,589	1,384	616	11,589
Single Lines ..	5,119	2,007	2,562	9,688
Total ..	14,708	3,391	3,178	21,277

We have here an increase in double lines from 7,000 to 11,589, viz., 4,589 miles; and in single lines from 6,000 to 9,688, viz., 3,688 miles. The figures applicable to 1872 are approximate, and are probably short of the actual mileage, the object being to show the increase in this respect as large as possible, for comparison with the increase in electrical appliances.

In quoting figures in respect of the latter, actual data is again absent, but figures of a near date enable a fair result to be reached. These figures show that in 1872 the mileage of wire was some 44,000, and the number of instruments 35,000; and that at the present time these quantities have increased, relatively, to 120,000 and 170,000 approximately. Wire has increased by 76,000 miles, and instruments by 135,000! Shall we try to capitalise this? Say £10 per mile for wire, and £5 per instrument, including batteries. £1,435,000! Nearly a million and a half sterling embarked within 25 years by railways in telegraphs needed for the conduct of their own traffic; added to which there is a mileage of over 88,000 miles of wire belonging to the State, for which accommodation is also found by the railways, and which is for the most part maintained by them. By far the greater part of this has been erected since 1872. Here, then, we have some idea of the work done upon railways within the last quarter of a century. Few will believe the value affixed above is in excess of that expended. All who have a knowledge of railway work will more probably consider the sum under rather than over-stated.

Naturally this large extension of wires has called for increased pole accommodation, and there can be no question that, even to the non-professional observer, large improvements in this direction have taken place. Lines of telegraph are constructed upon better principles. They are of greater capacity, and more strongly built, while the all-important question of insulation has not been neglected. Few, if any, railway companies now think of employing other than creosoted timber for poles; machine stranded wire for staying purposes; improved terminations; and generally a superior form of insulation. The ever-increasing demand for wires not unfrequently, owing to the circumscribed space allotted for the telegraph line, taxes more than ever the ingenuity and the resources of the engineer. Twenty-five years back lines of H poles were the exception. There are few main lines of railway now but present one, if not two, such lines—one on either side. With lines so loaded with wires sound staying is necessary for their security, and no hand-made stay can compare with that stranded by machinery.

If construction has advanced so has material. Nothing suitable to the purpose of a telegraph pole can excel in durability and general excellence the Norway red fir creosoted. In arms there is little change beyond the introduction of tubular iron arms, which are more compact, more durable, and save the deep slotting of the poles. G. I. wire has improved in conductivity, without appreciable loss in tensile strength; but the greatest improvement is to be found in the production of copper wire, and in its consequently largely extended use. For telephone circuits it is a necessity and is invariably used; but not a few of the leading companies are also erecting copper wire for all new circuits whether for message work or for block working. With the Post Office we know copper is being used mainly for its higher conductivity. With railway companies this is not so pressing a question. Railways do not employ high speed automatic telegraphs; but they aim at economy, and it is believed that copper wire will prove more durable than iron. Lines are therefore now built to carry copper wires of 150 lb. to the mile in preference to iron; and where renewals are carried out in smoky districts copper is generally used. With the introduction of heavy copper wires an improved form of binder has been found necessary and is now generally adopted.

The character of the telegraph instrument has undergone a gradual although not a very marked improvement. In Ireland the instrument employed in the transmission of messages is generally the Morse sounder. In England and Scotland the single needle predominates. The old double needle has quite succumbed to the single needle. Although naturally the greater amount of message work gravitates towards the main and subsidiary centres of a railway system, the flow of work is not of that magnitude which characterises the business passing between large commercial centres over the Post Office wires. Railways, so far, have not felt the need of automatic transmission. Wheatstone apparatus finds no place; nor has it been necessary to call in the aid of multiplex telegraphy in any of its branches. Quadruplex has however been adopted to the wants of, at least, one company, and duplex by more than one of the leading companies. Although the Phonopore has been for some years before the telegraph engineer, its progress has not been very marked. It is used, but to a small extent. In principle—regarding it as a means of communication—it is capable of being superimposed upon other telegraphic circuits, as for instance a wire employed for working duplex between two main points, and imposing upon it phonoporic apparatus between the same stations or between others on the route of the wire. We thereby obtain in practice the service of another wire or of sections of a wire; but this is obtained at the cost of considerable induction upon neighbouring wires, and unless negatived by the duplication and crossing of such wires, is found to much interfere with all sensitive apparatus—especially telephones. Otherwise the phonopore would prove of great service.

The telephone on railways, of comparatively modern introduction, is now one of the most useful and largely used of telegraph instruments in aid of the traffic. By its means signal boxes are able to communicate one with another to ascertain the position of trains, and so regulate their movement. To fully appreciate its value we must gain acquaintance with the working of lines north of the Thames, whose traffic throughout the 24 hours is of the most mixed character, where goods and mineral trains intermingle with fast and slow passenger trains; and yet where it is necessary to afford precedence to certain of all classes. With the convenience now enjoyed in this respect, it appears somewhat marvellous how such aids were dispensed with prior to their introduction. Their employment to any marked extent dates from the expiration of the Bell and Edison patents, and the extent to which they are now employed shows how highly their utility is appreciated by the railway management.

In block-signalling the forward movement is chiefly marked by its adoption throughout the railway service. All railway traffic is now conducted under the protection of electric block-signalling. Another great feature is the fact that the single-wire, or momentary current system of signalling, is fast giving way to the three-wire or permanent signal system. The period under review has also been productive of a system of working single lines of railway which has immensely improved their position, and put an end to those tiresome detentions which occasionally occurred owing to trains failing to keep time, or otherwise getting out of course. This has been the systems introduced by Tyer, known as the *Tablet* block, and that by Webb & Thompson known as the *Electric Staff*. The principle governing the two systems is the same. The staff or the tablet is the emblem of authority for a train to traverse the section inscribed upon it. Both driver and

guard must see it. But one emblem can be out—that is in use—of the pair of instruments which constitute the two ends of the section of line at the same time. The withdrawal of it from the instrument at either end automatically so arranges the electrical and mechanical parts of the instruments at each end that until the emblem so extracted has been restored to one of the two instruments no other can be obtained. With this apparatus—either the tablet or the electric staff—a train once clear of the section, another from either end may be allowed to enter.

In Ireland the type of Block in use is usually *Tyer's*, *Harper's*, *Preece's*, and Tyer's *Tablet* or Webb & Thompson's *Electric Staff*. For details of the description of block and other details in relation to Irish railways, the author is indebted to Mr. Tatlow, the General Manager of the Midland Great Western of Ireland. For similar details in relation to the form of block employed on the railways of Great Britain the reader should refer to the author's recent book on the Application of Electricity to Railway Working. They are too numerous to insert here.

Block-signalling as at present conducted is incomplete. The electric signals form in fact a portion of the signals of the section. It is by them that the signalman works his outdoor signals for the guidance of the engine-driver; but he may work, and in fact does work them independent the one of the other. It has for years been recognised that the two should be so interlocked that the mechanical signals should not be worked without the necessary operation of the electric signals. A means of effecting this was, in conjunction with Mr. W. H. Preece, introduced by the author in 1870, and it was rapidly followed by Messrs. Saxby & Farmer with a more complete system, but from that date onward, with the exception of the Chatham and Dover Railway, little advance has, until very recently, been made. Including the Chatham and Dover line there would appear to be some 513 miles of line now so provided. The lines most prominent in its application appear to be the London and South Western, 286 miles; the Great Eastern, 95 miles; the South Eastern, 77 miles; Brighton and South Coast, 54 miles; Midland, 40 miles; Caledonian, 35 miles; and the Manchester, Sheffield and Lincoln (now the Great Central), 16 miles. The Chatham and Dover is interlocked throughout.

In block-signalling accessories the enormous expansion which has taken place in the number of instruments tells to how great an extent electric signal repeaters, light indicators, crossing indicators, platform bells, point indicators, and many other special and peculiar appliances have within the period under purview swelled the result. The exigencies of the times and the urgency of all railway traffic is indeed such that if by any means work can be facilitated, or the movement of traffic rendered more secure, it is necessary it should be done, and in meeting many such demands electricity has, in the hands of the representative electrical officers of the several railway companies, become a ready and a useful agent.

The practical application of electricity to railway train lighting dates from 1881, when a Pullman car was fitted with accumulators. The cells were charged each night by a stationary engine and dynamo laid down for the purpose at the Victoria Station of the London, Brighton and South Coast Railway. Prior to this, experiments were made by both the Lancashire and Yorkshire Railway and the Great Eastern, but they were not successful. On the Brighton line the lighting of one car soon led to the lighting of others, and eventually of complete trains. The Midland and the Great Northern also made extensive experiments, and the light is still in operation on some of the latter company's trains. On the Midland, difficulties arising owing to the occasional interposition of unfitted stock, combined with the comparative ease with which a gas lighted coach could be dealt with, eventually led to the adoption of gas. Many other companies have made and still are making experiments. The progress, so far, although not remarkable, is such as to indicate an ardent desire on the part of railway companies to avail themselves of its advantages. There can be no question of the preference shown by the travelling public for the electric light. Gas lighting is undoubtedly a great advance upon the old form of oil lamp, yet it is not in all respects that which is desired. Associated with the use of gas—whatever may be its form or mode of application—whether for domestic purposes or purposes of a more special character, there is ever present a fear of the possibility of something happening. Nor has electricity gained entire confidence; but, whereas with the one we fear some unseen and hidden danger, with the other the feeling of the public is more that they do not understand than that they fear the consequences of its use. Train lighting by electricity is destined to come into general use, and were it possible to dispense with the use of accumulator batteries to-morrow, or to produce an accumulator battery capable of withstanding the rough treatment railway travelling imposes upon it, there is no doubt that the progress of railway train lighting by electricity would be greatly accelerated.

The present position of this branch of the subject is as follows:—On the Great Northern of Scotland some 40 carriages are being experimentally lighted. On the Caledonian there are two trains. The Great Northern has some eight trains. The London, Chatham and Dover some ten coaches. The South Eastern several vehicles devoted to their Continental traffic. The London and Tilbury has several coaches fitted. The Brighton Company has 41 trains lighted, and others about to be fitted. The London and North Western have only gone so far as to light the Royal Saloon, although, as will be remembered, this company, some few years since, had a fitted train working between Liverpool and Manchester.

In Ireland, the Great Northern of Ireland have, it is said, definitely adopted the electric light in certain of their most important trains—the system adopted being practically that originally employed by the Midland of England, viz., a dynamo driven off the axle of a vehicle and accumulators in each coach. The Midland Great Western is experimenting with Stones' system, as are also several other companies; while the Waterford, Limerick and Western Railway have, it is stated, permanently adopted it on a portion of their stock.

Of the many needs which, in railway working, electricity meets, to none would it appear more suited than in the establishment of passenger and guard communication. Yet, strange to say, with two solitary exceptions, viz., that of the Hull and Barnsley line and the main line trains of the London, Chatham and Dover line, its adoption has made no progress—why this is so it is not easy to say. Few will think the "cord" system meets all that is required; while recent events have demonstrated the need not only of a ready means of communication, but its application to slow trains as well as fast trains. The solution of the question is attended with some difficulty. To be of service in the prevention, or repression, of outrage, the means for operating the communication must be within ready reach from any part of the vehicle, and yet beyond the interference of children. The introduction of such a means of communication would unquestionably tend to remove from the minds of many travellers the fear and distrust which they now experience, and would, few will doubt, from the fact of its ready application prove a deterrent to crime.

The South Eastern and the Brighton Companies have employed an electric means of communication from the first; the Hull and Barnsley line have also, from the opening of that company's system, adopted electricity. The Chatham and Dover have subsequently established it on all main lines, and it is to be applied to all new stock. Mr. Fletcher, of the London and North Western, writes, that in corridor trains they have a system which, when a lever is pulled over, bells are set ringing in all the vans on the train and continue to do so until the attendant replaces the lever. In some instances the company is employing in each compartment a press button with an indicator over the door of each first-class compartment, and to each third-class carriage, to indicate when used. This indicator also, of course, requires to

be restored by the guard, or other attendant, before the alarm signal raised by pressing the button is relieved.

To many the extent to which electricity in its higher branches has been and is being employed will prove perhaps the most interesting portion of these remarks. The application of electrical energy to power purposes in connection with the general railway system—that is, apart from the actual operation of railways, such as the Liverpool Overhead Railway and the City of London line—has not been great. It has been observed that railways are conservative in principle. In no instance is it more observable than in the adoption of electrical energy to any one of the many purposes to which in locomotive workshops, carriage and waggon shops, urgency works in connection with tunnels, bridges, &c., it is capable of rendering serviceable aid. Many of these shops employ shafting and belting by the mile; many of the tools driven by this means are tools requiring the exercise of some power, to which might be applied motors, either direct or by reducing gear. The great loss due to shafting and belting alone is not recognised, or if recognised the exigencies of the moment, the fact that a mechanical system is perhaps better understood, has been already provided, or other equally cogent reasons would appear to prevail, and thus defer the date when greater advantage may be taken of that which is so ready at hand. At the same time, although these are facts patent to all, we must not lose sight of another equally stern fact. The price of motors and the cost of substituting electricity for mechanical driving is in many instances a deterrent. Will the cost come down? These observations, although general, do not of course apply so strongly to newly established shops or works. Companies about to extend their works, or to lay down new ones, will do well to bear in mind the advantages of electricity as a combined means for lighting and power purposes.

At the commencement of the period we are discussing, electrical energy for power purposes was not in use, and its application in this branch has been both limited and recent. There have been one or two pioneers. Mr. Webb, of the London and North Western, and Mr. Aspinall, of the Lancashire and Yorkshire, have both applied it with success for motor purposes. The Midland is also about to employ it for pumping, traverser, and lift purposes in connection with two installations now approaching completion. There should be a large field for electrical energy in traversers, capstans, and crane work, and no doubt the day is not far distant when applications in this direction will be made by some of the railway companies.

Turning to lighting we get greater encouragement. It is clear that railway companies are awakening to the many advantages of the electric light in the handling and disposal of their traffic. In goods yards, marshalling grounds, warehouses, and offices, it is finding considerable favour, and were it not for the heavy cost attending its establishment its progress would have been much more emphasised. It is, of course, an application peculiarly applicable to the period under review, and almost wholly so within the latter ten years. It may therefore be anticipated that its progress during the next decade will be much more marked. At present we find it in use on the London and North Western, Midland, Great Northern, Great Eastern, Great North of Scotland, Caledonian, Glasgow and South Western, North Eastern, Lancashire and Yorkshire, Manchester and Sheffield (now the "Great Central"), London and South Western, London, Brighton and South Coast, Chatham and Dover, Great Western, and South Eastern, as also on the Great Northern, and the Great Southern and Western lines in Ireland. In all, the Electrical Horse Power employed for electric lighting on railways in the United Kingdom, may be set down as approximately 17,000. The largest installation is that at Liverpool Street, London, the capacity of which is 3,200 E.H.P. The largest general user is the Midland. It is difficult to place an accurate money value on this large plant, but probably we shall not be far wrong if we estimate it at, inclusive of all charges, £60 per E.H.P.; £1,020,000 spent by railway companies in the electric lighting of stations, goods yards, offices, and warehouses, within so recent a period is indisputable evidence of the interest which railway companies have displayed in its advancement, and their appreciation of its advantages. These figures, it will be observed, apply to stationary installations only—not to train lighting. In that also money has been freely embarked.

It is not the purpose of this article to treat of the general advances made by railway companies in the interest and comfort of their patrons; still they go hand in hand with the various appliances of electricity. The one is indispensable to the other. The man who is able to carry back his mind to the conditions of railway travelling in 1872, and compare it with the conveniences of to-day, cannot but recognise how great has been the advancement; and that it has been of a stable and gratifying character, one of which our country may be proud. The third-class passenger of to-day accomplishes his journey in less time, and with largely increased comfort, than he could have done 20 years back. Improvements in signalling, improved locomotives, and a superior permanent way, have led to an increase of speed, and a decrease of casualty. But all this has not been the outcome of a day. Its accomplishment has been gradual; and such may be said of the progress of electricity in its application to the railway service.

TWENTY-FIVE YEARS OF TRANSMISSION OF POWER BY ELECTRICITY.

By RANKIN KENNEDY.

Twenty-five years ago the principal machine used in transmitting power electrically—the dynamo—had just been designed on the lines with which we are now so familiar. The ring armature had been brought out by Gramme, and the drum armature by Hefner Von Alteneck; the birth of the Electrical Review and that of the modern dynamo were contemporaneous. The writer had the benefit of seeing both of them in their infancy, and contemplates with pleasure the marvellous growth of both during the past quarter of a century. The development of the dynamo during the first seven years of its life was remarkably slow, and considering that the correct lines of design had been struck in 1872, it is surprising how little was done with it till 1880.

The discovery of the principle of the reversibility of the dynamo dates from the Vienna Exhibition of 1873, and is claimed for M. Hippolyte Fontaine as the result of a happy thought. Another version of the discovery is that it was a mere accident. At the 1873 Vienna Exhibition two Gramme machines were exhibited, one in motion, the other still. A workman seeing some cable ends dangling loose near the motionless machine, and thinking they belonged to it, coupled them into the terminals, when to everybody's surprise the machine started off running, receiving current from the other dynamo. So the stories go, but there is reason to believe that the idea of driving one electrical machine by the current generated by another is older than that; but the Vienna Exhibition marks the first point in the career of the dynamo as a motor in public.

The dynamo and motor first figured at a public exhibition in Great Britain at the Loan Collection of Scientific Apparatus of 1876 at South Kensington. In France in 1878 electric transmission of power was adopted in sugar works at Sermaize for working an elevator and was afterwards there extended to working mechanical ploughs. Then, in 1880, we had the great display of dynamos, motors, and electric lamps, at the Paris Exhibition, followed by a still greater display in 1881 at the Crystal Palace, Sydenham. In that year the possibilities of the dynamo began to dawn on engineers, capitalists were interested, money was lavishly expended in improving the machine, and money was squandered in plenty on dynamo designs which were worthless. From all this expenditure of brains and money about

that time very little progress was really made, and of all the wonderful machines then promoted none at this date remain intact. Some have been improved so that one would hardly recognise them, the others have been improved off the face of the earth.

Up till 1881 dynamos were built without much regard to the magnetic circuit, and it was a deep-rooted belief that motors and dynamos required to be designed on totally different lines. The next great stride in the progress of the machine was made when the principles of the magnetic circuit were elucidated for the benefit of practical engineers by Dr. John Hopkinson and Mr. Gisbert Kapp. What a thorough revolution these scientifically trained engineers made in the designing of magnets can only be realised by those who were in the electrical engineering profession 15 years ago, and witnessed the monstrous designs prior to their work.

Up till then the polarity of magnets seemed to be the only property studied for practical purposes, and it was only the effects obtained round about magnetic poles which were given important attention. When the recognition of the magnetic circuit principles became general the dynamos were then much improved in their field magnets. Other engineers investigated the collecting of the currents and the armature reactions, until by 1885-86 the dynamo assumed its present proportions; inefficient and expensive machines began to disappear, and now at the present day we find makers of dynamos all over the world working on two or three very simple designs—bipolar, multipolar, and ironclad.

For a long time only transmission of power requiring high pressure to long distances was considered by electrical engineers, but long distance transmission is a special subject which is not likely to be of much commercial interest for some time to come to the ordinary engineer. But the transmission of power in factories, mills, mines, shipyards, and so on is at present assuming a very important position as a market for the disposal of the dynamo maker's products. Here we have a practical illustration of the fact that developments often strike along lines least expected. In long distance work the dynamo competes with compressed air, or teledynamic cables, and the advantages are obvious; but in industrial transmission it competes with shafting, belts and pulleys, and at first thought one would readily conclude that these simple, well known, mechanical appliances could not be successfully displaced by the dynamo and electric cable. When, however, we face the questions squarely and go into them fully, we find that electrical transmission is superior *even at short distances*, and saves money all the time it is at work.

In shipyards, rolling mills, mines, and other places, power is distributed largely by steam, each machine to be driven having a self-contained steam engine; this is the most wasteful system possible, and in these cases the electrical engineer can demonstrate an immense advantage in favour of electrical transmission. In such instances the savings made, after adopting electrical driving, pays for the electrical plant in seven years' time, in the majority of cases.

The other case where electrical transmission can be introduced against all competition is in new works. Here the electrical engineer can collaborate with the architect for the buildings. The buildings can be very much improved in convenience, in natural lighting, and reduced in first cost if electrical transmission is adopted. This is no theory, but a plain fact, for the author in one case had buildings designed for belts, pulleys, shafting, gearing, and all the rest of mechanical transmission paraphernalia, and another design for the same buildings with electrical transmission, and the difference in favour of electricity was nearly £2,000. In cases of new factories the power and light plant can be very economically worked together.

As to the question of systems of driving the machinery, in many cases counter shafting must be used, but should be abolished wherever possible. Motors should be geared direct, each motor driving one machine, and completely under the machineman's control. If a counter shaft is necessary for speed purposes, it ought to be part and parcel with the motor, and some motors have reducing gear very nicely enclosed on their framework. While on these points of detail it may be worth while referring to another. Makers of motors should realise the importance of *completeness*. A motor does not always require a counter shaft, but they always require starting switches with some resistances. This fact does not even yet seem to have struck the majority of manufacturers. It would pay some enterprising firm to make a substantial, plain, serviceable starting switch for motors from a quarter to 5 horse-power. It wants no enamel, lacquer, or so called finish, for we cannot put a £5 switch on a £30 motor. What is wanted is a substantial instrument, like a steam valve or gas tap. It would be quite as reasonable to send out a motor without a commutator as to send it out without an efficient switch for starting!

The ideal motor for industrial electrical transmission is self-contained, and ready for work when delivered. It has resistances, switches, fuses, and counter shaft, all combined, made up in good workmanlike style; but with none of the absurd philosophical instrument gilt and lacquer. Such motors are now to be had from up-to-date makers, and are a great improvement on the motors requiring a separate switchboard and cumbrous shafting and belts.

Enclosed or ironclad motors are necessary in positions where they are exposed to dirt, wet, dust, flying cinders, and sparks of metal, but in other situations they have nothing to specially recommend them.

So far, continuous current motors have been considered.

Alternating current single phase motors have been designed to meet the demands of those unfortunate enough to be within reach of an alternating current supply only; they are troublesome and inefficient and cannot at present compete with the common continuous current motor in transmitting power, so one need not refer to them here at any length.

The polyphase motor aroused great expectations at one time, but these have not been realised. As an interesting study they cannot be surpassed, but as practical appliances for transmitting power they have considerable drawbacks, and curiously enough we find those most interested in polyphase patents using for the most part the common Gramme or Von Alteneck dynamo in filling contracts for transmitting power. Like the shaft, belt, and pulley of the mechanical engineer, the polyphase motor is not so simple as it looks; if it is to be perfectly under control in speed, in stopping and starting with all kinds of loads on, it requires expensive auxiliaries in the shape of non-inductive resistances, contact rings and brushes, which far more than counter-balance any advantages due to the abolition of the common commutator and brushes of the continuous current motor. The polyphase generator and distributing system in transmission plants are at least 25 per cent. more costly than the ordinary continuous current plant, and for these reasons it has made very little progress in short distance transmission.

Finally, the best system for workshop transmission is the simplest, and in most cases a plant consisting of two or more direct coupled engines and dynamos speeded to about 450 revolutions, or steam turbines at 10 times that speed, giving 110 to 220 volts with plain two-wire distribution, and ordinary motors with plain substantial switches is found best. Higher pressures may be used, but it is doubtful if the saving in copper thereby effected is not more than swallowed up in extra insulation and care required; higher pressures have been used in transmission in mines, 500 volts and even 700 being in use, but these are for comparatively long distances.

About a shipyard, an ironworks, or a factory, simplicity in generating plant, in distribution, in switches and motors is the secret of success.

The manufacture of small motors on a systematic scale has not yet in this country received much attention, hence they are comparatively expensive, but the growth of electric transmission in workshops will no doubt bring to the front well-made little motors at low prices. Motors over 3 or 4 horse-power are rarely required in driving single machines, and prices for these larger

machines are reasonably low; but when we come to 1 horse-power, or less, they run up in cost considerably.

In this country cheap power for distribution is not available in many places, but there is a great quantity of heat to be had at next to nothing from blast furnaces which might be converted into electrical energy and transmitted to consumers, but that and the utilisation of water power cannot be discussed in this article.

There are many examples of power transmission already in existence in works, and they are multiplying daily, so that this branch of electrical engineering has already assumed considerable magnitude, and perhaps the most complete example in a colliery is to be found in the Ackton Hall Colliery at Featherstone, belonging to Lord Masham. In conclusion, it is but right to mention that in the growth of the motor and dynamo, compound winding was invented by S. A. Varley, as also was the self-exciting principle in dynamos. The self-regulating properties of shunt wound motors was discovered by Mr. W. M. Mordey in 1886. The law of efficiency of electric motors was given to us by Sir William Siemens in 1877, by whom it was first applied to motors in practice. This law had, however, been stated by Lord Kelvin (then Prof. Thomson) in 1851 and was understood by Joule; it however remained a mathematical abstraction until Siemens's application of it. Till the expounding of the true law of efficiency by Siemens, Jacobi's law of maximum work had been mistaken for the law of efficiency.

Prof. Ayrton's paper on "Electric Transmission of Power," read at British Association Meeting at Sheffield in 1879, is perhaps the earliest thoroughly scientific discourse on the subject.

Seven years ago the author fitted out a large factory with 700 16-c.p. lamps and 60 horse-power in small motors. That plant has been increased since and not five minutes' time has been lost in that factory in 7 years due to any trouble with the electric plant, and the same firm is now installing 300 horse-power, to be subsequently increased to 600 horse-power, for complete power and light plant in a new factory. And a complete plant in which every machine will be driven by a separate motor, all fitted on the most approved methods, will be shortly completed in a new printing works at Leeds, and no doubt other engineers could fill up a list of similar plants, so that although this transmission of power in works does not bulk largely in print, it is to the ordinary electrical engineering firm of more importance than electrical traction or even central station work.

TWENTY-FIVE YEARS' PROGRESS IN ARC LIGHTING.

By R. E. CROMPTON.

Although the Electrical Review is desirous to record 25 years of progress in arc lighting, yet the writer, although he believes he was one of the very first in this country to deal with arc lamps, cannot go further back than the year 1878; in that year he purchased in Paris two Serrin lamps and two Gramme dynamos, and these were set to work in the newly erected pipe foundry of the Stanton Iron Works Company; shortly after that two other lamps and Gramme machines were added, and in following out the vagaries and various weak points of these Serrin lamps the writer received his first education in practical electrical engineering of the modern kind. Although at that date, 1878, several other types of lamps had been described and some of them used in laboratories, yet the Serrin lamp was the only one which, at that time, had been manufactured in considerable quantities and had attained commercial success; at that time it cost £25. It was beautifully made but was somewhat difficult to adjust—the arc was struck by the depression of a rectangular frame by means of an electro-magnet in the main circuit. The electro-magnet was placed in an inclined position and its armature attached to the moving frame was so fixed that when attracted by its magnet it moved through a long stroke across the face of the poles. As the arc lengthened by the burning away of the carbons, the current through the magnet was thereby reduced and the pull weakened, and the frame rose until at a certain point of its stroke a detent on the last wheel of a train of clockwork was released, and the upper carbon was free to descend and make a feed motion. From this parent mechanism the modern arc lamp has been evolved. The first thing the writer did was to construct a lamp with the mechanism above the arc instead of below it, as in the Serrin pattern. The next thing was to arrange that two or more lamps could be burnt in series. Dr. Hopkinson had already, in one of his writings, pointed out that the working of the Serrin lamp could be improved by adapting a shunt magnet coupled across the arc so that its action would oppose that of the main electro-magnet. The writer applied this idea to working lamps in series, and in 1879 had already manufactured several of these lamps; they were worked off an "A" Gramme speeded up so as to get sufficient voltage to work two lamps in series. A year later in 1879–80 the Burgin machine was introduced, which could be readily wound to give sufficient EMF to drive three lamps in series and a considerable amount of arc lighting (among which may be named the original lighting of King's Cross Station) was carried out with these early series lamps driven by Burgin dynamos. About the same time series lamps were sent over from America and the first display of series arc lighting on an extended scale took place in Hatton Garden, the Brush Company having sent over one of their 14 light machines wound to give an EMF of 700 volts and driving 14-10 ampere lamps in series. We then became acquainted for the first time with the Brush clutch lamp and the very beautiful device of dashpots, cut outs, &c., connected therewith, and which were really a marvel of ingenuity and design when we consider the extremely early period in the art at which Mr. Charles Brush brought them out. Brush's inventions were very quickly followed by other forms of American lamps, and for a long time the great extension of arc lighting was in America and was chiefly in the form of series arc lighting; this class of arc lighting, which has met with such success in America, has never been adopted to a great extent in this country, one reason, no doubt, being that it does not allow of very perfect and steady lighting and consequently is not well adapted for interiors, another being that it filled a want, *i.e.*, of providing for the street lighting of a large number of towns in America where there was no gas, and this want did not exist in England to an equal extent. The developments of arc lighting in England therefore took place chiefly in connection with the lighting of docks, railway stations, workshops and other business premises, and in carrying out this work great advances were made so that when the supply companies and municipal authorities had laid their mains and were ready to supply continuous and alternating currents from central stations, the lamp makers, both in England and on the Continent, had already so far improved the designs of arc lamps, and improved the manufacture of carbons, that they were able to fix lamps to burn on these supply systems and to give results, both as to steadiness and brilliancy, far surpassing what had been obtained in America, although as to numbers of lamps, America had had so enormous a start.

Everyone knows that the practical introduction of burning arc lamps in parallel on constant potential circuits dates practically from the Inventions and Colonial Exhibitions, which were the last two of the series of exhibitions held at South Kensington; previous to that time attempts had been made to burn lamps in parallel circuit, but without success—as it was found that whenever the lamps were coupled direct on to a circuit approximately of the voltage required for burning them either in single parallel or in parallels of two-each series they jumped or vibrated excessively. The only lamps that then appeared to obtain some measure of success on constant potential circuits were those worked by the Gülcher Company. No doubt one reason why so little was done in this direction at the time was,

first, the absence of any large systems of electric supply worked at constant potential on which such lamps could be tested, but mainly due to the very important fact which had not been then noticed, *i.e.*, how very simply the difficulty of the pulsation of lamps in parallel circuit could be got over, *i.e.*, by the introduction of a resistance in series with each lamp, which resistance must absorb approximately five to eight per cent. of the circuit voltage, which voltage must be to that extent in excess of that required by the lamp. As far as the writer is aware the practical knowledge of this fact was confined to the Gülcher Company up to the date when Messrs. Siemens and the writer's own firm exhibited lamps worked in this manner in parallel on a 60 volt circuit at the Colonial Exhibition in 1886; but even then the application of lamps burning on constant potential circuits did not receive much attention until such constant potential circuits were laid down for the supply of incandescent lighting in Berlin, London, and elsewhere. As these constant potential circuits were never under 100 volts, and more commonly reached 110 volts, the efforts of arc lamp manufacturers were directed to the production of pairs of lamps to burn two in series steadily and satisfactorily on circuits of this voltage; and this branch of arc lighting has now arrived at a high degree of perfection. It has been extended gradually up to burning four lamps on 200 volt circuits, five lamps on 235 volt circuits, and nine lamps on 460 volt circuits.

The problem has been approached in two distinct ways. On the Continent of Europe, *i.e.*, first in Germany and at a later period in France, what are called shunt lamps were principally used. In these lamps the regulation of the feed of the carbons is affected solely by an electro-magnet or solenoid wound with a fine wire coil, the terminals of which are connected across the terminals of the lamp. In some cases a series coil is also used to strike the arc at starting through a fixed distance and to hold the arc striking mechanism, and thus the arc, firmly in one fixed position so long as the lamp is alight, but these may still be classified as shunt lamps for the series coils so fitted take no part in regulating the length of the arc, which duty is performed solely by the shunt coil. At an early date English practice diverged from Continental practice in this respect. The lamps which have always found most favour in this country have not been shunt lamps. They have been balanced lamps in which the shunt coil is made to pull against and oppose the action of a series coil, the series coil tending to open the arc, and the shunt coil to close it. Owing to the opposed action of the two coils, each of them has to be larger and more powerful than the shunt coils of the shunt lamps so that the wire required is more than twice the quantity and costs twice as much, and the writer believes that a very strong reason why the shunt lamp found such favour among Continental manufacturers was the very great reduction in the weight, and hence cost of the winding and magnets that it allows of. Shunt lamps, although they present this advantage from a manufacturer's point of view, however well they may be designed and made, always present one great difficulty when two such lamps are burned in series. This is due to a phenomenon which has never been thoroughly explained, but which is always noticeable, *i.e.*, that the very slight changes of potential which occur in each lamp between two successive periods of feeding produce very much larger changes in the current passing through the two lamps than ought to be the case. If two shunt lamps A and B are connected in series on a 100 volt circuit with suitable resistance in series with them to ensure steady burning, it will be found that if the lamps A and B are each regulated to feed exactly at 43 volts, what will happen will be this:—When the lamps feed at 43 volts, immediately after the feeding the volts of both will drop to 42; the total difference of potential across the terminals of the two lamps will be 84, consequently the variation of potential across the two will be from 84 just after the period of feeding to 86 just before the next feeding movement takes place; in other words, that the irregularities due to feeding are additive instead of cancelling one another as one would naturally have expected. The curious thing is that the current passing through the two lamps instead of varying in the same proportion as the volts from 44 to 46, varies in a very much larger proportion, *i.e.*, if it were 10 amperes at 42 volts it will fall as low as seven amperes at 43 volts, hence results a considerable change in the intensity of the light, for although this does not take place suddenly, yet the slow variation in intensity is extremely trying to the eyesight, and this is particularly noticeable where such lamps are used in drawing offices or similar situations where the maintenance of constant illumination is of importance. This variation of intensity, which is very noticeable in the lamps seen in German towns, and in certain German made lamps imported into this country, is never seen when properly designed balanced lamps are used. The two principal makers in this country invariably use balanced lamps, and the perfect regularity and steadiness of the many splendid examples of arc lighting that may be seen not only in the streets and public places, but also within doors in this country, is very greatly due to the almost universal adoption of the balanced principle.

Up to the year 1890 the balanced principle was frequently applied in the form of two solenoids placed in one line pulling on the two ends of a continuous core, or of two cores connected together so as to form a continuous bar; but since the year 1890 nearly all the balanced lamps have consisted of two separate solenoids, generally placed vertically, pulling on the two opposite ends of a balanced lever, to one of the moving parts of which the arc striking and feeding mechanism is attached. This arrangement of two solenoids placed side by side has the advantage of favouring compactness and solidity of construction, and at the same time, reduces the friction of parts to that of pivots or pins of small diameter instead of sliding surfaces as was formerly the case. The cores of the solenoids are also balanced, and thus the lamps are not affected by shaking, such as in the act of raising or lowering the lamp, or if swinging from the yardarm of a ship. In these balanced lamps the function of the main coil is to take up and compensate for any variation in the voltage of the supply system, and any irregularities in the resistance of the arc due to impurities in the carbons. The holding of the carbons in correct alignment in many patterns of lamps still follows the original arrangement, *i.e.*, of fixing the upper carbon to a vertical rod which is free to slide up and down, its motion being controlled either by some form of clutch mechanism operating on a smooth rod, or by some force of brake mechanism operating on one or more brake wheels which are caused to revolve by the descent of this vertical rod which in the majority of cases has a rack cut on one side of it for this purpose. Clutch mechanism, introduced on a commercial scale by Brush in 1880, has never found great favour in this country; it works well when new, but works badly and irregularly when the rods have been constantly cleaned and by the action of the clutch loose their smooth surface, and in place of it present a more or less irregular and serrated surface to the action of the clutch. When this condition of affairs takes place the feed movements are no longer approximately equal in amount but are very irregular, and hence every feed movement is accompanied by corresponding irregularity in the burning of the lamp. When rack mechanism is used any such chance of irregularity must be attributed to irregular action of the brake on the circumference of the brake wheels, but as these brake wheels are never exposed to the action of the gases from the arc, in fact, as they are generally protected within the lamp, it is easy to keep them clean and truly cylindrical enough for the purpose, all that is necessary being that the material chosen for the brake shoes should be suitable, and in this particular rather a vast amount of experimenting has been carried out. Several materials appear to be of equal merit for this purpose, the main necessity being that the material of which the brake shoes are composed should be of softer material than the brake wheel. Rubber acts exceedingly well but it is not durable, and hence requires frequent renewal.

When the material for brakes is properly chosen the brake wheels wear equally all over, so that an old lamp works quite as well as a new lamp. Recent progress in this part of the mechanism has been such that the brake mechanism of modern English arc lamps of the best make has been perfected to such an extent that the feed movement is almost continuous and extremely regular; in fact, in these lamps such irregularity as is ever observed in the burning does not in any case arise from the irregularity of the feed mechanism as used to be the case years ago, but solely from irregularities or impurities in the carbons as will be noticed later on.

It is in the design of the carbon rod and controlling mechanism that American practice has varied most widely from English practice in arc lamp construction. In America the clutch lamp and solid carbons are still largely used, and, in fact, up to quite a recent date an American writer on the subject still points out that the rack and pinion lamps which are used in America, although satisfactory for indoor work, are not so well adapted for outdoor service or rough usage as the clutch lamp, and he states the reason for this is that in America rack and pinion lamps are much more liable to stick and fail to feed than the clutch lamps, for it is better for the carbons in feeding to drop together like a ton of lead rather than to stick at the feed; this is, of course, due to the fact that the majority of lamps in America are still running on series circuits and that the sticking up of one lamp has a much more serious effect than the sticking up of one of two, or one of four lamps as they are commonly used on constant potential circuits in England, but the writer considers that this opinion is founded on the comparison of the two classes of lamps as they exist in America, and not on the comparison of the clutch lamps as they exist in America with the rack and brake lamps that are manufactured in this country.

But apart from this question both in England and on the Continent, considerable attention has of late years been given to band or cord lamps, in which the rack rod or clutch rod is entirely dispensed with, and the lamp thereby considerably shortened. Another point on which English practice has differed somewhat from Continental and American practice, has been that in England solenoids have been used in preference to electro-magnets, as in this way a long pull can be obtained with much greater certainty, and without the necessity for such accurate workmanship as must be employed wherever long pull electro-magnets are used. One somewhat difficult study has been that of alternating arc lamps; the alternating current when employed in arc lamps presents considerable difficulties which are not met with in continuous current ones; the first and chief one being that as with the alternating lamp a considerable portion of the light is thrown upwards where it is wasted, it is necessary to maintain a reflector very close to the arc so as to divert these rays into a useful direction. Another difficulty has been that of obtaining the requisite electro-magnetic control with the weaker action of alternating currents. Again, when alternating lamps are placed in series necessitating the use of shunt currents, the amount of the shunt current has to be very much larger in order to obtain the requisite shunt control than is the case with continuous currents. If we add to this that the electro-magnetic effects of alternating currents vary very considerably, not only with the periodicity, but also with the characteristic of the alternators, and as no two generating stations in England are alike in these respects, it will be seen that arc lamp manufacturers are placed at considerable disadvantage in supplying lamps for these circuits, as the winding and electro-magnetic conditions of the lamps have to be varied for each case. Another difficulty with alternating current lamps has been that the vibrating action of the current has a great tendency to make brake or even clutch lamps slip and so allow the carbons to feed together until they come in contact. One of the best devices that has been arranged for working the lamps on alternating circuits has been to adopt small transformers, each capable of working one, two, or three lamps independently. This device shows considerable economy when any of these lamps have to be switched on. Transformers thus arranged were described by Elihu Thomson under the name of compensators for three-wire distribution. There have also been considerable developments of a very simple form of burning alternating lamps in series with a reactance coil in shunt to each lamp. The choice of carbons for alternating lamps has been far more difficult than with continuous lamps. Even at this date admirers of solid carbons are to be found, but the weight of opinion appears to lie in favour of employing cored carbons of the highest grade for upper and lower, and both with soft cores. Mr. Ferranti has paid great attention to the conversion of alternating currents into unidirectional pulsating ones; this he calls rectification, and the conversion is carried out by a piece of apparatus called a rectifier. A considerable number of these rectifiers have been used in this country, and with conspicuous success, sufficient of the alternating current being taken off the main bars and converted by the rectifiers into rectified currents of high tension for working street lamps in series. Such lamps have all the advantages of continuous current lamps in that there is a definite positive carbon, which has a crater and throws its light downwards; the rectified current, as regards electro-magnetic power, is about midway between ordinary continuous and the alternating currents, but the slight vibratory action of the rectified current makes it easy to work the lamps and to get excellent results.

ABSOLUTE MEASUREMENTS.

By PROFESSOR A. GRAY, LL.D., F.R.S.E.

The advances in practical electricity during the last 25 years have been enormous, and it is not too much to say that that progress has been in no small degree due to the adoption of an absolute system of units for the measurement of electrical quantities. It is true, also, that practical applications first demonstrated the necessity for such a system. If, for example, the constants of a submarine cable at the time of laying were known only in terms of the results of tests made by means of such-and-such instruments in the possession of the manufacturer, the question as to what changes are brought about in it by continued immersion in sea-water could not be answered with anything like accuracy, if it could be answered at all.

The truth is that neither the engineer nor the physical theorist or experimenter can be allowed to self-complacently appropriate all the credit for what has been achieved. Each has done good work, and the work of each has been the gain of the other. But when the march of progress is looked back upon it ill becomes either the engineer or his colleague to claim credit for all that has been accomplished. The men who indulge in such silly glorification of their own order by so doing retard that onward progress which is the very life of science. For their judgment as to what is important in knowledge and research is occasionally received and acted on with a deference quite beyond its due.

Twenty-five years ago the British Association system of units had just taken shape. In the way indicated in some of its main lines by Gauss and Weber, electrical and magnetic quantities were henceforth to be measured by units connected with those of dynamics, and independent of the constants of the instruments or the circumstances of experimenting of any investigator. Thus the results of experiments on electrical constants made anywhere and in any circumstances were, when expressed in such absolute units, placed at the immediate disposal of experimenters everywhere else. Labour was no longer wasted as it had been before, comparison of methods and results was rendered possible, and the questions which practical applications had begun to put could be intelligibly answered. The effect of this alignment of the forces of investigators was soon felt. The realisation of the electrical standards defined in the absolute system of units was taken in hand by experi-

menters all over the world, and it soon became possible to agree upon proper mean results for use in practical work.

Physical theory and practical application both owe a deep debt of gratitude to the British Association Committee on Electrical Standards. Their system of units in the opinion of some may not be all that it might be; but it has done an enormous amount to rescue engineering from chaos and uncertainty, and to make electricity the science of exact measurement which it now essentially is. Also the long continued series of comparisons of standards undertaken by the Committee, and carried on in late years with so much expenditure of skill and labour at the Cavendish Laboratory, under the supervision of Mr. Glazebrook, deserves the hearty acknowledgment of all electrical workers.

In reviewing the work of the B.A. Committee and the investigations suggested in great measure by their reports, one naturally thinks first of the determination of resistance in absolute units. The first determination was probably that made by Kirchhoff nearly 50 years ago, by the now well-known method of induced currents. That was followed about 1852 by the publication of the methods of W. Weber, and in 1863 by the B.A. determination carried out by Clerk Maxwell, Balfour Stewart and Fleeming Jenkin, by the method of the revolving coil suggested by Thomson. These latter experiments, elaborate and careful as they were, have since been found to be in error by something like 1·3 per cent., and the comparatively recent careful repetition of the determination by Lord Rayleigh and Prof. Schuster will always remain a monument of experimental skill and resource continued over a long series of arduous observations.

Such early determinations as those of the British Association and others paved the way to the series of accurate determination that have been made during the last quarter of a century. Kohlrausch carried out, in 1873, a determination by Weber's method of the damping of the oscillation of a magnet within a coil in the closed circuit the resistance of which was to be found. Kirchhoff's method was revived and applied to a careful realisation of the ohm by Rowland at Baltimore, and by Glazebrook at Cambridge. After a trial of Weber's other method, that of the earth-inductor, by the inventor himself in conjunction with F. Zöllner, it was successfully employed in a fairly exact measurement of resistance about 1884 by G. Wiedemann, and again by Mascart, de Nerville, and Benoit.

But the greatest step in advance in this subject was undoubtedly that made when Lorenz, of Copenhagen, invented his revolving disc method in 1873. A metal disc touched near its centre and at its edge by the terminals of a conductor is spun round its axis at a uniform observed speed, in the magnetic field of a coil coaxial with the disc and carrying a current. The electromotive force in the circuit thus formed is balanced by the difference of potential between the terminals of a resistance, through which flows the coil-current or a known fraction of that current. All that is to be determined is, then, the mutual inductance between the coil and the edge of the disc, and the speed at which the disc is rotated when balance is maintained in the disc circuit.

This beautiful method, as has been shown in an extremely valuable paper by Lord Rayleigh on the "Comparison of Methods for the Determination of Resistance in Absolute Measure," which appeared in the *Philosophical Magazine* for November, 1882, has from the nature of the measurements involved in it advantages over all others; and this conclusion has been amply verified by the consistency of the results obtained from it in the hands of different experimenters.

The method has been used by Lorenz himself, by Lord Rayleigh and Mrs. Sidgwick, and more lately by Prof. J. V. Jones of Cardiff. The latter has had the coil and disc made with all the precision to be obtained from Whitworth lathes and the most refined engineering workmanship, and has applied the method to the direct measurement of the specific resistance of mercury and the construction of low but accurately known resistances. The extremely elegant stroboscopic method of determining the speed of the disc first employed by Lord Rayleigh was used, and an elaborate series of observations was made. The coil was wound in a single layer in an accurately cut screw-thread, and the inductance was very exactly computed by a mathematical method of Professor Jones's own invention. He has also been able with his appliances to measure a small outstanding ellipticity of the cross-section of his coil, and to estimate the necessary correction. His final result, on the supposition that the resistances of certain coils which he used have been exactly determined in terms of the international ohm, is that the value of the international ohm is ·99998 of a true ohm.

Professor Jones has thus greatly improved the Lorenz apparatus, and his experience of its use enables him to speak with authority as to its capabilities. He considers that at present the resistances of coils, and the specific resistances of materials, can be known from the experiments that have been made, within limiting absolute values differing from one another by 4 or 5 parts in 10,000. These limits would, he believes, be brought much closer, to at most 1 part in 10,000, if secondary standards of resistance were continually brought into comparison with a Lorenz apparatus properly made, and placed in a fully equipped electrical laboratory, for example, the Government Standardising Laboratory.

For some time, Professor Jones has been engaged with Professor Ayrton in a redetermination by means of a new apparatus, of Professor Jones's pattern, made lately by Messrs. Nalder for the McGill University, Montreal, and we understand that there seems little reason to doubt that the results of this investigation will confirm his contention that the Lorenz apparatus can be constructed, and with proper care used, so as to be the most trustworthy primary standard for resistance.

As we write, interesting information (derived from these experiments) on the important question of the permanence of resistance coils has been published by Professor Ayrton.

The mean result of the best experiments is now approximately expressed by the decision which has been come to to define an ohm for practical purposes as the resistance at 0° C. of a uniform column of mercury weighing 14·4521 grammes in a tube 106·3 cms. long. This corresponds to cross-section 1 sq. mm., and density of mercury 13·5956.

In connection with these results it is worthy of notice that a comparison of the very careful determinations of the dynamical equivalent of heat made by Rowland in America by the direct method, and by E. H. Griffiths and by Schuster and Gannon in this country by the electrical method, has suggested that possibly the standards of resistance or of electro-motive force, or both, are in error to a certain extent. The results of the determinations by the two methods, when freed from all thermometer errors, and expressed in terms of the dynamical values of the specific heat of water at different temperatures, show over the range of temperature, for which Griffiths' experiments were made, almost exact parallelism, indicating some constant source of error between them. This result is very interesting, and shows that great exactness can now be obtained in such a very difficult measurement as that of the energy-value of the specific heat of water; but it seems more than doubtful if the cause of the discrepance can be that suggested.

As all electricians are aware, the ratio of the electromagnetic unit of quantity of electricity to the electrostatic unit is by Maxwell's electromagnetic theory of light propagation equal to the velocity of light. Within the last 25 or 30 years a series of exact comparisons of units have also been made by which the value of this important constant has been found to a considerable degree of accuracy. Various methods have been suggested, and all are of great theoretical interest. Some three or four have, however, been mainly used. So far back as 1868 a determination was made in Lord Kelvin's laboratory by McKichan, who measured electrostatically and electromagnetically one and the same electro-motive force. This investigation was one

of the first in which the absolute electrometer, the most wonderful of all that wonderful series of electrometers which Lord Kelvin has given to electricians, was turned to scientific account. With to some extent the same apparatus, but with some changes of procedure, this investigation was repeated about 14 years later by Mr. R. Shida, a Japanese student of great promise, whose early death was a distinct loss to science. About the year 1868 also, Maxwell carried out a determination by practically the same method, but using a specially constructed and very remarkable apparatus, by which the attraction between two oppositely charged discs was balanced by the repulsion between the currents in two flat coils attached to their backs.

Since that time careful determinations, by comparing the measured electromagnetic value of the capacity of an air condenser with the calculated electrostatic value, have been made by Profs. Ayrton and Perry, Prof. J. J. Thomson, Mr. E. B. Rosa at Baltimore, and by Prof. J. J. Thomson and Mr. Searle. In the determination of the last named, the stroboscopic method was used to determine the speed of a commutator which charged and discharged the condenser, and the investigation was in other respects of a very elaborate and complete nature.

The method of electrical oscillations has also been employed, first by Lodge and Glazebrook, who discharged an air condenser through a circuit containing a coil of measurable self-inductance and a small spark-gap. Electrical oscillations were set up and a spark was produced in the gap which, photographed on a plate revolving at a known rate, enabled the period to be formed. From this and the other data the capacity of the condenser was computed.

The general result of all these experiments is a velocity of light on Maxwell's theory of very nearly 3×10^{10} cms. per second; that is to say, the same value as is obtained by direct observation of the speed of propagation of so-called visible light.

Much has been done in this country and on the Continent in continuation of the early work of Gibson and Barclay, Boltzmann and others on specific inductive capacity of dielectrics. Hopkinson in this country, and Quincke, Silow, Klemencie, Negreano, and many others on the Continent, have obtained results of great theoretical importance, as bearing on Maxwell's theory that the specific inductive capacities of dielectrics, which have all approximately the same magnetic inductivity, are proportional to the squares of their indices of refraction. The wonderful verification of Maxwell's theory which was carried out only about 10 years ago by Hertz, has developed entirely new ways of determining electrical quantities. It is possible now to measure the lengths of electric waves, and, as had been previously done, to determine their period. Thus it is possible to compare, for example, the capacities of different condensers, and so find by means of rapid electrical oscillations the dielectric constants of different materials. This branch of research has already yielded many valuable results, and there seems some reason to hope that by the use of rapid oscillations the question of the inductive capacity of bodies of sensible conductivity may be fully investigated experimentally before long.

A remarkable determination of the so-called time of relaxation for a condenser (the time in which, after removal of the charging battery, the difference of potential between the plates falls to $1/e$ of its initial value), made by Cohn and Arons for water as dielectric, may be mentioned in this connection. This gave for the inductivity of water the value 75·6.

The immense amount of valuable work which has been done by Ewing, Hopkinson, Du Bois, and others, on the absolute determination of magnetic induction, permeability, &c., in iron and other metals, is discussed elsewhere; but we may merely mention here Dr. Taylor Jones's experiments on magnetic traction in iron, which he has pushed to the enormous induction of 74,200 C. G. S., and corresponding intensity of 51,000 C. G. S. These experiments have shown that Maxwell's expression $B^2/8\pi$ holds for the electromagnetic stress in the narrow air space between two surfaces of iron, through a range of induction from 6,000 C. G. S. up to the value just quoted.

The same investigator has just published the results of a research, carried out at Bangor, on the relation between magnetic stress and magnetic deformation in nickel. This gives the remarkable result that, after the effects of known stresses are allowed for, a very considerable alteration of length remains, which, within the range of experiments made, is closely proportional to the fourth power of the magnetisation intensity.

We can only refer further to the great value of the work done by eminent electricians in the invention of electrical measuring instruments. Lord Kelvin's electrometers have already been referred to, and current-meters and volt-meters have been invented by him, and by Professors Ayrton and Perry, Mr. Mather, Mr. Swinburne, Major Cardew, and many others. Lord Rayleigh's work on the electrolysis of silver, and his absolute measurements of currents by the current-weigher, together with the careful investigation of copper electrolysis made by T. Gray and others, has enabled such instruments to be calibrated to a degree of accuracy sufficient in many cases for very exact laboratory work. Lord Kelvin's series of balances are now in constant use, for example, in many standardising laboratories and testing rooms.

As an outcome of all this valuable work on standards, the Electrical Standardising Laboratory has been established at the Board of Trade, and now under the care of Major Cardew, and with the authority of the Order in Council with respect to practical electrical standards, provides for the electrical industry that regulation which the department of weights and measures exerts on the buying and selling of ordinary goods.

This laboratory is already equipped with much valuable apparatus for the absolute measurement of currents, &c. But it should be in possession of *all* the primary standards; and it is to be hoped that there will soon be installed in it, what it does not possess at present, a Lorenz apparatus, which should be of the most accurate construction at present possible.

It is much to be hoped that this institution may be only the earnest of a great national laboratory, which shall undertake to answer, with all the help available from engineering, dynamical and electrical skill, those important questions of exact measurement which practice and theory will persist in putting, and which private enterprise cannot be expected to provide for. Thus great service will be done not only to electrical engineering but also to abstract physical science, which two must ever for their mutual advantage go forward together.

TWENTY-FIVE YEARS' DEVELOPMENTS IN TELEPHONY.

By J. E. KINGSBURY.

Twenty-five years ago the electric speaking telephone did not exist. Its name had been earlier applied by Wheatstone to acoustic transmission, and by Reis to the electrical apparatus to which he had devoted much research, and upon which he founded great hopes; but the problem of electrical speech transmission was not solved until 1876 by Alexander Graham Bell, a native of Edinburgh, but then a United States citizen, resident in Boston. His discovery was no happy accident. The successful inventor is largely the creature of his environment, and from his boyhood Bell had breathed an atmosphere of speech analysis. His father was a professor of elocution and the inventor of a system of "self interpreting physiological letters for the writing of all languages in one alphabet." The system was put to a severe test, described by Mr. Alexander Ellis in a publication called the *Reader*, of September 3rd, 1864:—

"Mr. Bell sent his two sons, who were to read the writing, out of the room . . . and I dictated slowly

and distinctly the sounds which I wished to be written. . . . The result was perfectly satisfactory. His sons, not having heard my queer and purposely exaggerated pronunciations, so uttered them as to surprise me by the extremely correct echo of my own voice."

This mode of writing was thought to be of National or International importance, and was offered by its inventor to the Government, but the offer was declined and subsequently the system was published in book form in 1867, under the title of "Visible Speech."

The work is dedicated "to the memory of Edward Charles Bell, one of the first proficients in 'visible speech,' . . . but whose life of highest promise was cut off in his nineteenth year on May 17th, 1867." One son was unhappily taken, but the other was left and was destined to confer a greater benefit on humanity by extending the limits of audible speech than by demonstrating the utility of "visible speech." Alexander Graham Bell accompanied his father across the Atlantic, and added some practical experience in electricity to his knowledge of acoustics, combining them in inventions having for their object the improvement of telegraphic methods. In these were partially utilised those researches of Helmholtz which eventually led to the invention of the telephone.

Some years after the electrical transmission of speech had been brought to a successful issue, Professor Tyndall, remarked that "it never could have been expected that these slight variations in resistance and in the strength of a current could produce such marvellous effects." Bell experienced this doubt beforehand. He was satisfied of the principle, confident in his knowledge of acoustical phenomena, but he was a little doubtful whether he had the necessary electrical knowledge to devise the apparatus which should give effect to his conception. In October, 1874, he had a conversation with Dr. Blake, when he outlined the principle in his mind; and subsequently Bell explained his ideas and expressed his doubts to Professor Henry. Should he publish his proposals and leave to others their fulfilment? or acquire the necessary experience himself? Henry's advice was to the point, without any wasted words:—"Get it." And he got it. 1876 saw the practical realisation of the idea of 1874. More prompt recognition of utility and merit was probably never accorded any invention. Bell's electric speaking telephone was sent to an exhibition and submitted to judgment. It was fortunate in its judges. One of the greatest mathematicians and practical electricians of his age, approaching it from the scientific standpoint, observed that its inventor had first the mathematical conception, and then, by a process which he described as the hardihood of invention, had devised instrumentalities for realising that conception. Then, approaching it from the point of view of a practical electrician, he described it as "the greatest by far of all the marvels of the electric telegraph."

Having been invented and its powers recognised, the scope of its utility had to be considered, and it is surprising now to recall the comparatively limited anticipations of the usefulness of the telephone. Houses and stables, offices and workshops were to be connected; perhaps a string of houses were to be in communication, but Lord Kelvin went further than that. He went so far as to express his conviction that the time would come when we should be summoned to the telegraph office and there converse with our correspondent who would await our arrival at the other end of the line. And all the time Lord Kelvin's native Glasgow possessed a telegraphic "exchange," an institution which might also have been found in such other cities as Newcastle in England, New York and Philadelphia in the United States. The use of the telegraphic exchange was very limited. Perhaps those first interested in the development of the telephone were not aware of its existence, and those who knew were probably satisfied that the telephone was too much of a scientific toy to be taken into account. Whatever the cause, it is safe to say that when first submitted to public patronage the field of usefulness that lay before it was not foretold. But few months were needed for the discovery to be made. The attachment of telephones to a series of burglar alarm wires, to a district telegraph system, to a telegraphic exchange system, sufficed to demonstrate that the means of communication, hitherto stopping at a telegraph office and needing the assistance of an expert intermediary, were now brought to one's own house or office and used without skilled assistance. Telephone Exchanges were started with the original Bell instruments, but developed rapidly with the introduction of battery transmitters.

In considering the advances which have been made in the speaking instruments, it is remarkable how nearly existing types conform to their originals. The latest Bell receiver is the same in form as the first single pole instrument commercially used, but the interior construction has reverted to a still earlier type in the use of both poles of the magnet. Scientific investigation and manufacturing experience have done much to ensure high standards of efficiency and uniformity of results, but the Bell instrument as used to-day is the same in every essential respect as the instrument which Bell put upon the market. The transmitter has gone through more changes and been the subject of more controversies. The first commercial transmitter was that of Edison, who devised a theory for its action which it was not constructed to efficiently carry out in practice. Hughes's discovery of the microphone explained the action of the transmitter, and Hunnings found, in powdered carbon, the most suitable form of material with which to obtain the necessary current changes. Hence, nearly all forms of transmitter now used, come within the scope of Hunnings, and are classed as microphones of Professor Hughes, who had, in fact, experimented with all forms of carbon and described them in his account of the discovery of the microphone principle in 1878, although it must not be forgotten that Berliner had, in 1877, described and specifically applied to a telephone transmitter the microphonic principle of variation of resistance due to relative intimacy of contact. The Berliner form was followed in the Blake transmitter, which has done good service and still remains an excellent instance of a clear transmitter, giving good results on short lines and especially suitable for earth circuit working by reason of the small battery current sent to line, the consequent feebleness of induced currents and limited extent of disturbance in neighbouring wires. Neither Blake nor Hunnings were commercially connected with telephone work. Francis Blake was an officer of the United States Coast Survey, and Henry Hunnings was a curate of the Church of England.

Although the instruments used for speaking have undergone only slight changes, the accessory apparatus has been the subject of continual modifications. Commencing with battery ringing it was soon found that magneto-electric machines offered great advantages. The earliest were of the Clark form, but these were superseded by the Siemens' Armature pattern which was in general use by the early eighties and, except perhaps experimentally, was the only type used in England. The magneto is a combination of devices for despatching and receiving call signals and for diverting the telephone circuit. In each department great changes have been made. The earliest gearing was by toothed wheels, but they were noisy and friction gear or rubber bands were introduced. The latter, to ensure greater durability, were covered with a spiral wire. Improvements in manufacture and devices to reduce the noise, as in the Chicago magneto, have led to the reversion to cut gearing. It is difficult now to realise that the operations of diverting the telephone circuit and cutting in the generator were at one time performed by hand. The introduction of automatic devices for these operations were important advances, but both were accomplished in the early years of the industry. The operation of the telephone switch by gravity was introduced by Roosevelt. Different "cut-outs" have been devised. The one introduced by Williams has been most generally used, though the Post centrifugal form has been continued in some later makes. The changes which have been effected in the details of design and con-

struction are too numerous to be even mentioned. Whilst still a "magneto" the modern "bridging bell" will hardly be recognised in comparison with its earliest prototype.

But the greatest changes are to be seen in the switchboards and other central office apparatus for which a demand was created when the utility of intercommunication by telephone was demonstrated. Under a variety of names and with a variety of construction, they remained of one general type—which will be sufficiently understood by the word "standard"—until Scribner and his associates invented the multiple test system and developed the apparatus which made it possible to have numerous "jacks" for one line and permitted the connection of any two subscribers by one operator. The growth of the telephone system has been largely due to the invention of this apparatus. Without it the connections in any large exchange would have been almost impossible. At this date when we know that its adoption is so universal, it may be of interest to note the way in which it was introduced by its manufacturers. I quote from a catalogue of the date of which I am not certain, but judge to be about 1882. "It is becoming generally recognised that the multiple switchboard is the switchboard which will solve the problem of large exchanges. . . . It is a fact, that with this system two thousand or more subscribers can be handled in one office just as promptly and as satisfactorily to the subscribers as one or two hundred can be by any other system. At Indianapolis, with 900 subscribers in one office, the average time in making connections is *ten seconds*, counting from the time the drop falls; and this rate can be maintained with any number of subscribers which can be got into one exchange."

Since the above words were written, the number of subscribers which may be considered to constitute a large office has very considerably grown, but the multiple board, by successive improvement, has been adapted to the requirements of any exchanges so that the concluding words of the extract remain true—the advantages of the multiple system can be given to any number which can be brought into one exchange. Frequent alterations were needed with the development of the exchanges, but the considerable increase in the number of points of contact led to the necessity of a change of system, and this became still more apparent with the introduction of metallic circuits. Scribner, himself, made one of the first essays in this direction in what was known within very narrow limits as the "parenthesis system," and as the demand became more acute, various experts propounded the advantages of "branch terminal" jack contacts over the break form, and this gave rise to the now well-known "branching system" which was brought to a practical stage by Oro A. Bell, of the Western Electric Company's New York staff. The amount of work and attention devoted to the development of switchboard designs and mechanism is beyond narration. And this work has been of a very unusual character incident to the new conditions. Individual ingenuity and mechanical ability have been allied with the experience of practical users, so that new departures have been based on carefully organised information. Without this co-operation it is doubtful if the ever growing needs could have been met.

The branching system required considerable use of electric current, and with it commenced the reliance of a telephone exchange on the electric light station, until it has now become general for the town supply to provide current directly or indirectly to ring the subscribers, to restore the indicators, and to work the transmitters. Perhaps this partial familiarity may have led to the further extension in the same direction until the modern telephone exchange is itself a miniature electric light system, with small incandescent lamps to indicate to the operator the call and disconnection signal of the subscriber, which are automatically transmitted by the removal or replacement of the telephone at the subscriber's station. The first exchange to work on this plan is Worcester, Massachusetts.

Apart from the switchboards the central office apparatus has undergone considerable changes with the growth of the system. Subscribers' lines were originally brought to the switchboards as individual wires, more or less neatly arranged with wooden cleats or their equivalent; but the concentration of thousands of wires at one centre involved new requirements in the way of orderly arrangement, so that facilities for prompt investigation and repair might coincide with the exigencies of space. Combine with these conditions the necessary provision for changes in the relation of subscribers' lines to operators' positions and the necessity may be realised of Distributing Boards, Intermediate Distributing Boards and similar apparatus which have been devised in great number to meet the growing needs of the service. Lightning and Strong Current Protectors of elaborate construction add more material to the central office outfit. The elaboration is needed less for nature's electricity than for the strong currents produced for electric light or power; but if there is occasion sometimes to regret the existence of these stronger currents, there is also occasion to take advantage of them, for the "Power Board" in a modern telephone exchange consists of apparatus for diverting an electric light current into paths of usefulness to the telephone engineer.

The changes which have taken place in outside work have been as pronounced as those for central office apparatus, though necessarily fewer in number and involving less detail. Much of the outside work in the telephone's early days has been the subject of censure. Let it be remembered that in those early days there was some need for haste, some need also for economy and no particular experience to show that economy did not necessarily lay in the direction of "cheapness." Moreover, the service was new and experience had to be bought—and paid for. The means then existing sufficed for the immediate needs; lines were short, and disturbances not overbearing, hence iron wires, and those single, served well enough as a commencement. Since then self-induction, mutual induction, "K R" and other laws, have been the subject of scientific investigations which the telephone engineer has been able to utilise to the full largely by the improvements introduced in the manufacture of copper wire and cables.

How much of the improvement in telephonic communication is dependent on the material and construction of the lines can only be determined by comparison. In the winter of 1878–9 one of the first long distance experiments was conducted under the then available commercial conditions. It was over the private wire of Messrs. J. & J. Colman, between London and Norwich, a line distance of 115 miles. Edison carbon transmitters and Bell receivers were used. Conversation was possible, but the disturbances, attributed to induction, but, doubtless, largely due to imperfect joints, were more pronounced than the conversation. The receiver gave forth sounds which Mr. Preece has described as like the pattering of rain on the window pane, but more prosaically likened, by someone else then present, to "frying fat," and the conversation had to make its way through these sounds. A comparison of this experience with the conversation, distinct and free from interruption, as now attainable over the London-Paris, or Chicago-New York lines, is the best object lesson in telephonic progress.

The importance of metallic circuits which have been popularly christened "twin wires" has of late been much insisted upon, and sometimes in such a way as to lead to the impression that their advantages are of comparatively modern discovery. There are two Administrations which have used metallic circuits from the beginning—the British Government throughout their Exchanges, and the Telephone Administration in Paris, originally a private company, but for some years past under the French Post Office. Elsewhere the single lines were general, not because the importance of double lines was not appreciated, but solely from commercial considerations. So early, comparatively, as 1883 Sir Frederick Bramwell emphasised this fact, whilst at the same time

(*Continued on page* 669.)

A MODERN CENTRAL STATION.

The Lighting of Hammersmith.

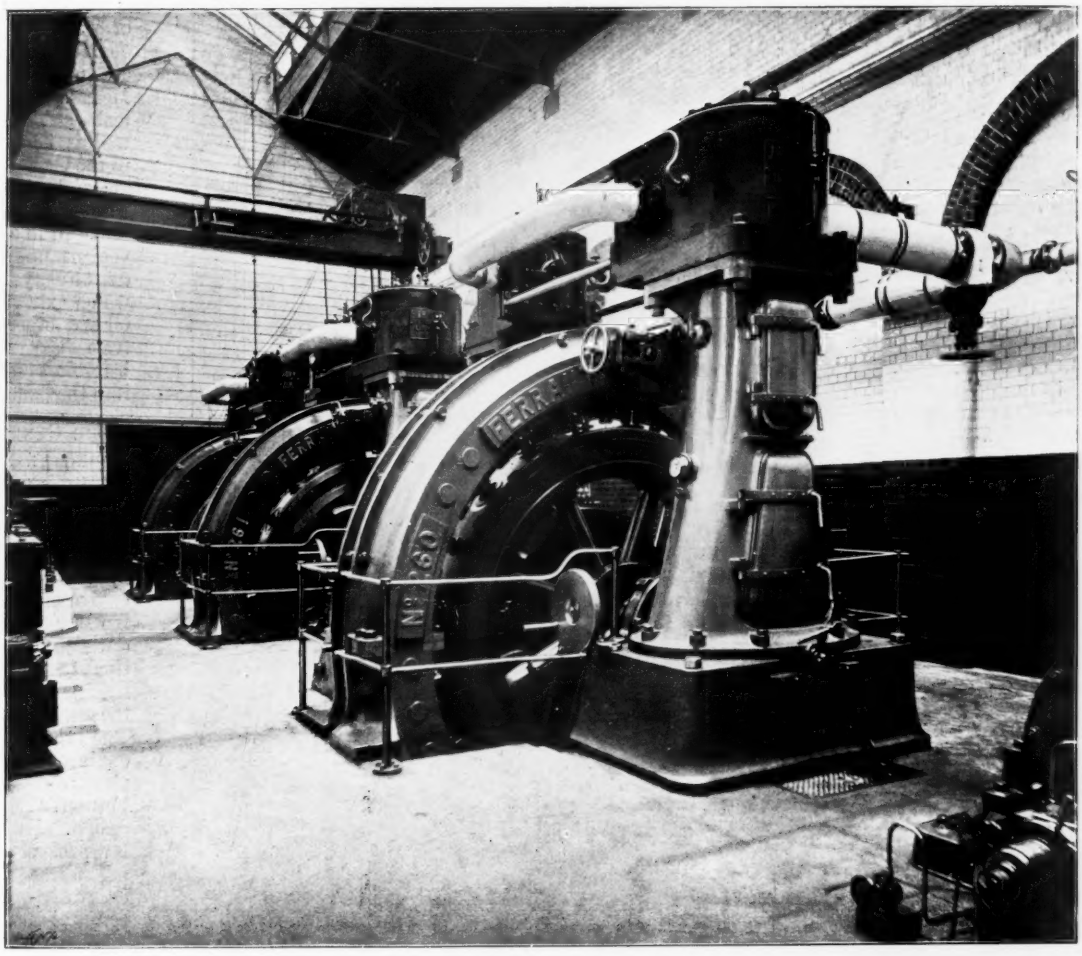
There is a certain fitness of things in including a description of the Hammersmith Vestry Electric Lighting Works in this number, for in many respects it undoubtedly represents the most modern high pressure alternating practice. It is hardly necessary to say that the design of central stations of the high pressure type has undergone many alterations during the past five years. Not for a moment can it be said that we have reached any degree of finality, but that we have made considerable strides cannot be denied. The most striking developments have been in the increase in the size of units, and the adoption of direct coupled plant. It may be of some interest to compare diagrammatically (see pages 665 and 666) the type of station of four or five years ago with one of the later type of works. The two stations have practically equal capacity, but the first (which, by the way, is not an old system) is of the rope driven small unit variety, once much loved by some engineers, and the second is the direct coupled moderate sized unit type. We need scarcely dilate upon the extraordinary disparity in the room occupied by the plant, and the marked difference that must arise in working the two stations.

Turning, however, to the Hammersmith station, the system is the high pressure alternating, generated at a pressure of 2,000 volts, and transformed in underground sub-stations to a low pressure current of 110 volts.

The boiler house plant consists of two Babcock and Wilcox water-tube boilers, fitted with patent superheaters, one Lancashire boiler and economiser, and the necessary feed pumps, pipes, &c. The Babcock boilers are each capable of producing steam for 250 horse-power. They have each a heating surface of 2,437 square feet, and a grate area of 44 square feet. The Lancashire boiler, which has been constructed by Messrs. Tetlow, is of mild steel, and it is 28 feet long × 7 feet 6 inches in diameter, and the two flue tubes are each 3 feet in diameter. This boiler will raise steam for 200 horse-power, and it is intended to be used during the daytime. Space is provided in the boiler house for a third Babcock and Wilcox boiler of the same size as the two existing ones.

The economiser is of Green's patent type, and it is used for heating the feed water required for the boilers by means of the waste gases in the flues. It consists of 144 tubes, 9 feet long and $4\frac{2}{16}$ inches in diameter. It is constructed on the latest principle with improved soot-cleaning apparatus, which is driven by means of an electric motor.

The feed pumps are in duplicate, and they are of the Worthington patent type. Each pump is $7\frac{1}{2}$ inches × 5 inches × 6 inches. They are each capable of delivering not less than 4,000 gallons of water per hour, and thus either pump is capable of supplying all the boilers, including the future one, with the requisite quantity of feed water. The feed pipe arrangements are very complete, and so designed that any or all of the boilers can be supplied independently, or at the same time, with hot or cold water, and the arrangements are such that the failure of any portion of the feed system will not interfere with the working of any of the boilers. The arrangement of the steam pipes for conducting the steam generated by the boilers to the engines is on the ring principle, and it is so divided up by valves into sections that the failure of any section will only affect the running of the engine or boiler connected to that section. The diameter of the main steam pipe is 7 inches, and there is also an auxiliary steam ring $2\frac{1}{2}$ inches in diameter, which provides steam for the feed pumps and other auxiliary apparatus. Each boiler is connected to this steam ring through an isolating valve, which prevents the possibility of any

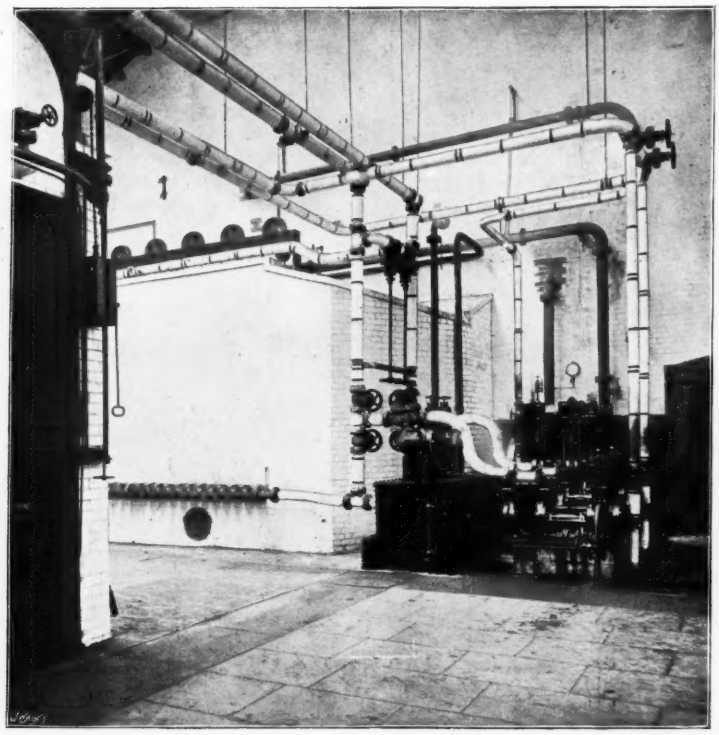


General View of Engine Room.

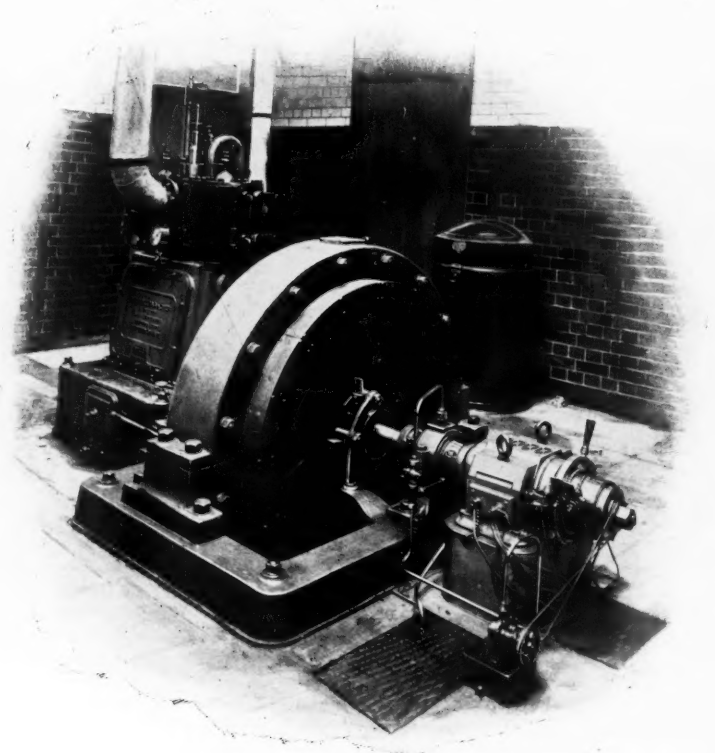
steam leaking back into a boiler which is not in use. Complete drainage arrangements with Geipel steam traps are provided to all the steam pipes, and all the water condensed in these pipes is taken into the hot well and used again in the boilers.

Condensing Plant.

The exhaust pipe is carried overhead in the engine room, and is 12 inches in diameter. It is connected to the condenser and also to the atmosphere, and arrangements are made so that in the event of the failure of the condensing plant, the connection to the atmosphere is automatically opened. The condenser, which is placed out of doors, is of the Ledward patent evaporative type, and it depends for its action upon the cooling effect produced by the evaporation of water, and the effect is increased by placing the apparatus in the open air. The exhaust steam is taken into a series of cast-iron pipes of corrugated pattern, and cooling water is pumped over the outside of the pipes, thus cooling them and condensing the steam inside them. There are altogether 160 of these pipes, each pipe being 5 feet long, and the condenser is sufficient to deal with the steam required by 400 horse-power. A large storage tank is fixed beneath the condenser, and arranged so that it can catch the cooling water of the condenser. This tank, which has a capacity of 4,000 gallons, forms the main storage supply to the building, and is connected to the main water supply of the parish. Arrangements have been made with the Water Company so that a duplicate supply is provided to the station, taken from two different points of their system, thus, if there should be a failure in connection with one portion of the public water mains, the station can still be supplied from another section. The feed pumps in the boiler house can also, if necessary, draw water direct from the company's mains instead of from the above-mentioned tank.



Economisers and Pumping Plant.



Day Load Plant.

The condensed steam from the condenser is drawn by the air pump, which is fixed in the boiler house, and delivered into a hot well, which is a cast-iron tank of 500 gallons capacity. The air pump is of Messrs. Allen's make. The hot well is connected to the feed pumps above described. Filters are also provided in a convenient position of the system, which extract the oil and other dirt from the water before it is pumped into the boilers.

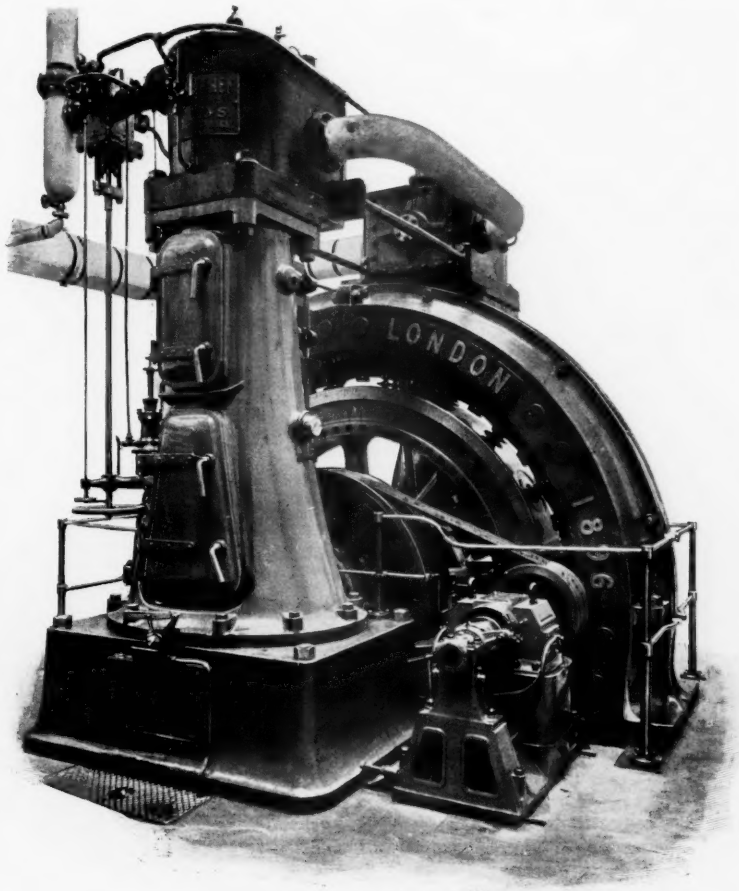
The Generating Plant.

The engine house plant consists of three main engines and dynamos, one small engine and dynamo for working during the daytime, the arc lighting apparatus, and the switchboard. The three main engines and dynamos are of Messrs. Ferranti's special design. Each set is capable of lighting about 4,000 8-candle-power lamps at one time.

The engines were made for Messrs. Ferranti by Messrs. McLaren, of Leeds. They are vertical compound, with most of the working parts enclosed, arranged to work condensing or non-condensing. The cylinders are mounted on cast-iron columns, which, with the crank-pits form enclosed chambers, in which the cranks and driving parts work. The valve gear is outside the columns, and with the exception of the rods and L.P. expansion gear, is cased in; thus securing the advantages of an open-type engine, with the absence of oil

and water where it is not wanted, *i.e.*, splashed over the alternator and exciter. The H.P. and L.P. engines are placed on either side of the alternator, and the cranks being overhung, only two main bearings are necessary. These are of exceptionally large bearing surface. The cylinders are, H.P. 15½ inches, and L.P. 25½ inches diameter, with a stroke of 18 inches, the engines running at 150 revolutions a minute. The H.P. slide valve is driven from a McLaren patent automatic expansion governor, which gives a maximum variation of 3 per cent. revolutions from no load to full load. The L.P. valve is driven through a link which, by hand regulation, gives a variable expansion on this engine. Inside each crank pit is an oil pump, driven by a dray link from the crank pin which keeps all working parts lubricated under pressure; this is usually kept at 20 lbs. per square inch. The stop valve, starting valve, byepass valve, and drain cocks are, by means of extended spindles, all brought within control from the engine room floor level.

There are in all four generators; three of 125-kwt. and one of 25-kwt. capacity. The larger machines are of the well-known Ferranti disc type, in which the armature coils are carried by holders securely bolted to and insulated from the fly-wheel. The coils are wound with copper tape over cores built up of hard brass strip carefully insulated. They are built in pairs, the holder forming the connection between the two coils. There are 20 such pairs to each machine, connected in two sets of 10 in parallel. The earth connection is made directly to the fly-wheel.



Combined Engine and Alternator.

The insulated pole is connected to a gun-metal collector ring, mounted on porcelain insulators. The fly-wheel is built in two halves, bolted together at the rim and further secured by steel rings shrunk in recesses at the joints, the wheel is fastened to the shaft by massive steel tyres, which are shrunk on in position, no keys being used. The diameter from tip to tip of the armature coils is 12ft. 6ins., and the total revolving weight 9 tons. The field magnets are carried in frames which surround the armature on either side, the frames being strongly bolted together. The field coils are of copper strip wound on edge, thus securing one layer only of winding with the best possible ventilation. The whole field winding consists of 80 coils connected in series. The exciters are shunt wound driven from the governor drum by ropes. They have been specially designed for rapid excitation, which is regulated by a resistance in the shunt. The frames can be easily opened out without disturbing any other part of the machine.

The day load set is capable of lighting 750 8-C.P. lamps at one time. The engine has been made by Messrs. Belliss. It is their patent closed-in high speed type, provided with forced lubrication. The speed of the plant is 450 revolutions per minute. The engine is compounded, and the high pressure cylinder is 7ins. in diameter, while the low pressure cylinder is 11ins. in diameter, and the stroke is 5ins. The governor is Messrs. Belliss' patent design, and controls the engine by means of a throttle valve. The dynamo is Messrs. Ferranti's revolving field magnet type with the armature fixed. The field magnet, which forms a fly-wheel, is provided with one large exciting coil. The armature is made up of a number of flat coils bolted to a ring surrounding the field magnets. The exciting current is supplied from a small continuous current dynamo attached to an extension of the dynamo shaft.

The arc lighting apparatus consists of 3 Ferranti rectifiers, the form of which differs slightly from those at Portsmouth and other places, as will be seen from our illustrations. Each rectifier is designed to light 50 12-ampere arc lamps. At present not quite 100 lamps are installed, so that one rectifier is used as spare.

There are two switchboards, one for the main dynamos and the other for the arc lighting circuits. The main switchboard is of Messrs. Ferranti's patent type which has been previously described in these columns. The board is divided up into panels, each dynamo and each circuit being provided with a separate panel. The board is entirely of slate, and is built into the wall of the engine-room. Each panel is divided from its neighbour by a slate partition, and the whole board is arranged so that it is practically impossible to touch any terminal or other metal which is in use and therefore dangerous. It is single pole, and each dynamo and each circuit is provided with a single pole switch, a fuse and an ammeter. The switches are specially designed with a very long break, and arrangements are made in the dynamo circuits, so that when each dynamo is being brought into parallel, connection is first made through a synchronising apparatus. The fuses are Messrs. Ferranti's patent oil spring type, and duplicate fuses are provided to every panel. Above the main switchboard the two main voltmeters of the Kelvin type are fixed together with the synchronising lamps. The circuits, of which there are four, are brought from underground up to their respective panels through special concentric fittings, and the outer, which is earthed, is connected direct to the earth bar at the top of the board.

The arc lighting board is of simple design. Arrangements are made for either of the three rectifiers to be connected to either of the two arc lighting circuits. Each circuit is provided with oil fuse and an ammeter and current direction indicator. The outer conductor of the arc lighting circuit is not earthed, and is carefully insulated throughout. Arrangements are provided in one of the rooms on the level with engine room for testing all the mains and other apparatus,

and testing plugs are also provided on the switchboard for each dynamo.

Distributing System.

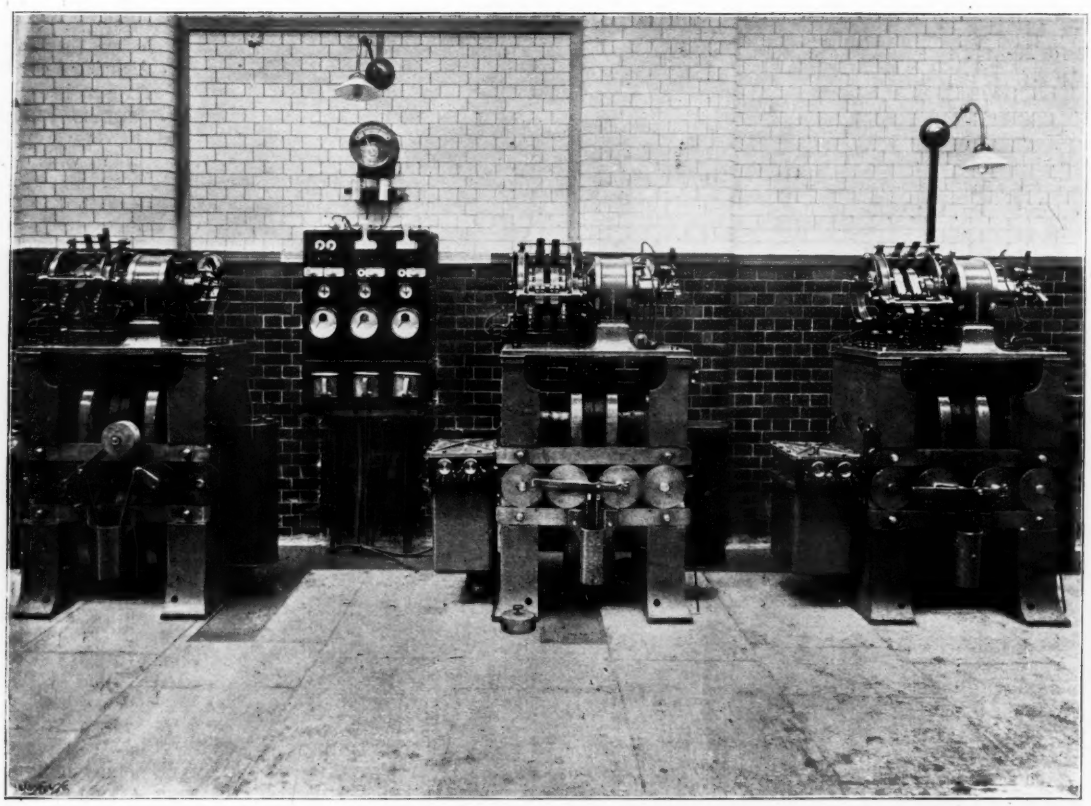
The current generated in the works is conducted to the various portions of the parish included in the provisional order as the compulsory area, by means of concentric cables laid throughout in cast-iron pipes. All draw-in boxes are, where possible, of cast-iron. The pipes in every box are plugged, and it is therefore hoped that gas will be effectually kept out. The whole of the contract for trenching, supplying, and laying pipes, providing cables, &c., has been carried out by Messrs. Callender. The high pressure cables, which are concentric and protected by lead sheathing, are of Messrs. Callender's patent jute impregnated type. The high pressure cables are connected to certain districts where sub-stations are placed, and in these sub-stations the high pressure is transformed, and the low pressure current produced is conducted by a network of low pressure mains along the various streets in the district. There are altogether four main circuits which are interconnected, so that the failure of any one circuit will not interfere with the supply to any particular district. Branch circuits are provided at the distributing points to feed the ends of the various districts. Besides the above circuits spare pipes are provided to the principal points, so that future circuits may be easily added. In fact, it is hoped that it will not be necessary to re-open for many years any of the streets which have been disturbed in laying the present cables.

The low pressure cables are also of Messrs. Callender's patent jute type, and they are protected by a lead sheathing, and also a double armouring of steel tape. They are laid direct in the ground beneath the pavement. The arc lighting cables are laid in a separate system of pipes throughout the area served, and in order to provide for the 85 lamps at present fixed, it has been necessary to lay two circuits. They are laid on opposite sides of the streets, thus in the event of the failure of either circuit the streets will not be placed in darkness. The whole of the high pressure and low pressure cables were tested after laying and jointing up to over three times the working pressure, and they all withstood this severe test satisfactorily.

Sub-Stations.

There are at present six sub-stations provided for transforming the high pressure current to the low pressure current. Except in the case of the Town Hall sub-station, which is placed in the basement of that building, all the sub-stations have been constructed in convenient positions under the pavement and roadway. Each sub-station is about 8ft. by 9ft. by 7ft. high, and access is provided by means of a manhole about 3ft. square. The transformers are made by Messrs. Siemens Bros.

The street lighting at present is by arc lamps, which are lighted from sunset to midnight, and after that hour glow lamps are used. The arc lamps, posts, &c., for which Messrs. Siemens were the contractors, are placed between 70 and 110 yards apart along the streets comprising the compulsory area.



View of Rectifiers.

The arc lamps are of the well-known Brockie-Pell type, each giving about 1,200 candle-power, and fixed 20 feet above the ground. On each post there are two glow lamps of 32 candle-power each, placed about 14 feet above the ground, and connected to the low pressure mains.

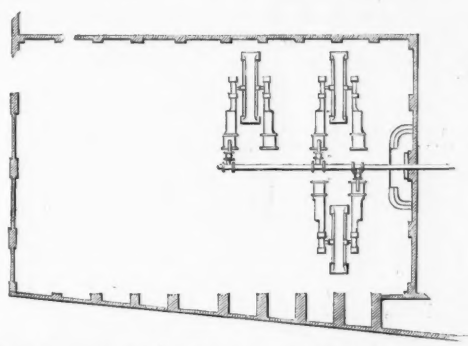
Mr. Edmunds's automatic switch, which has been described in these columns, is placed in each of the posts, and it is arranged that if, by design or by accident, any of the arc lamps go out, the glow lamps are automatically lighted by means of this switch.

The buildings have been designed and superintended by Mr. H. Mair, A.M.I.C.E., the surveyor to the Vestry, with Mr. Randall as Clerk of Works. Mr. A. H. Preece, A.M.I.C.E., has designed and superintended all the machinery and other electrical work. Mr. Bell has acted

as resident engineer, and has taken charge of the running of the station.

The total cost of the above scheme has been about £40,000, and the following is a list of the principal contracts which have been entered into, and other sums expended by the Vestry, excluding the cost of the land:—

	Contractor.	£	s.	d.
Excavation of site and carting away surplus earth ...	The Vestry	227	8	6
Foundations of buildings and condenser	" "	623	1	11
Buildings and chimney ...	Messrs. Leslie & Co.	6,720	17	5
Boilers, engines, dynamos and other machinery ...	Messrs. Ferranti	13,617	7	0
Travelling crane	Messrs. Marshall, Fleming & Jack	157	0	0
High pressure and low pressure cables and pipes ...	Messrs. Callender	10,170	2	11
Arc lamp posts	Messrs. Siemens	2,702	0	0
Making good trenches in street	The Vestry	1,625	0	0
Sub-stations	" "	335	8	11
Sub-station equipment and transformers	Messrs. Siemens	935	0	0
Consulting engineer, Clerk of Works, Quantity Surveyor and sundry expenses ...		1,400	0	0
		38,523	6	8

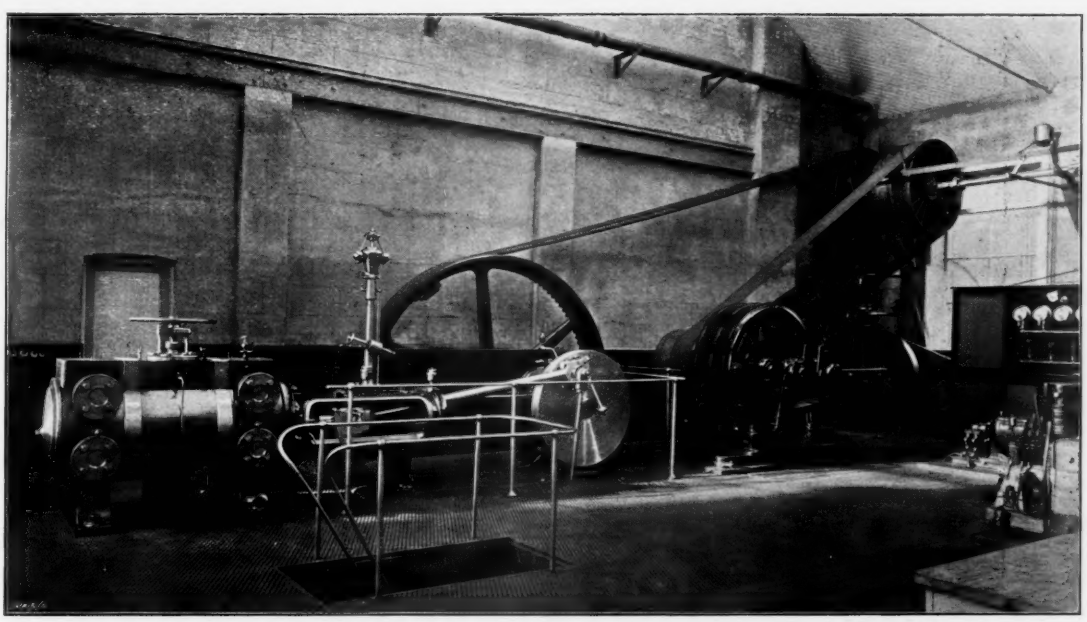


Direct Coupled Plant, Capacity of 660 Units (see p. 661).

THE INTRODUCTION OF MULTIPHASE WORK IN THE UNITED KINGDOM.

The question as to why multiphase work has not been more generally adopted in this country is one that must have occurred to many. It is generally conceded that a large measure of success has attended the systems that have been laid down in different parts of the European Continent and America, and these systems have been examined and duly praised from time to time by English engineers. At the same time there was—and, no doubt, there still remains—a feeling that there were certain limitations in a multiphase system. A commonly-expressed opinion was that though a multiphase system might show distinct advantages when used solely for power purposes, certain complications would arise if an attempt were made to do both lighting and driving from multiphase machinery. As a concession to this opinion, it may be pointed out that in some of the Continental stations where multiphase plant is employed, the three-phase current is merely transmitted to distant points, and there utilised to drive continuous current machinery. This does not, however, obtain in every case, for at Baden, Milan, and a large number of other places on the Continent, multiphase current is being supplied direct to both motors and lamps without causing, as far as we can learn, any complications. At Baden, Messrs. Brown, Boveri's shops are being driven from the town supply, which is on the two-phase system, and a considerable amount of lighting is being done, indeed the power required for lighting is about equal to that required for motive power purposes.

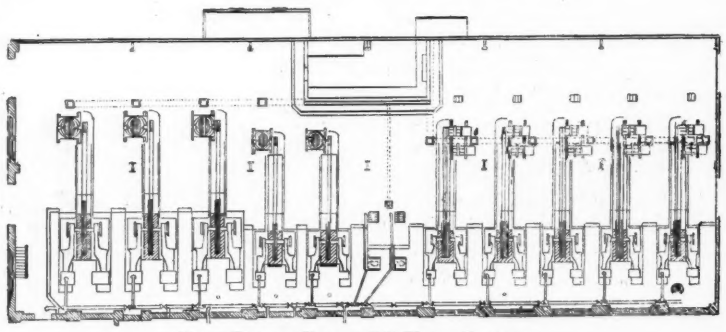
In spite of the reluctance of English engineers to take up multiphase work, it has been held that for some purposes the induction motor is most desirable. As was said some time ago in these columns:* "Now that the commutatorless motor is perfected in the form of single-phase, two-phase, and three-phase induction motors, these somewhat lame devices (enclosing motors and brushes) are not likely to be perpetuated. The only motor for fiery mains is the induction motor. They can be started with sufficient torque for all practical purposes, and are absolutely sparkless, and, in reality, much safer to handle than continuous current motors. This last claim for induction motors is generally overlooked, but



Single Engine Driving 80 kw. Generator at Messrs. Richardson & Sons.

* Rankin Kennedy, Electrical Review, Vol. 39, September 11th, 1896.

from the facilities offered in transforming the alternating currents used in induction motors, we can work them at much lower electric pressures than the continuous motor; for in order to run the continuous motor with wires at any reasonably low cost, we must use 300 to 700 volts right up to the motor. We cannot transform down to 100 or 50 volts as we can with the induction motor. Using the induction motor, we can transmit a large power at very small loss through thin wires to a long distance, and then still be able to apply a low pressure to the motor."

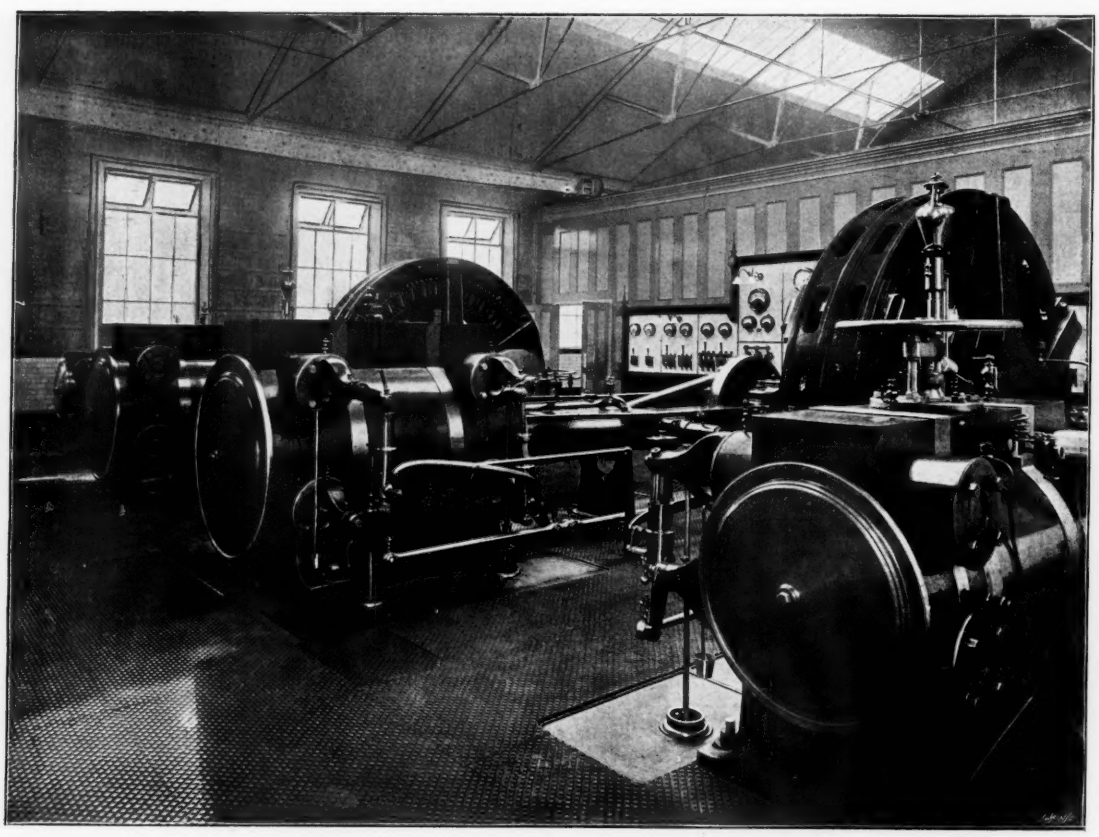


Rope Driven Plant, 650 Units Capacity.
(See page 661.)

The foregoing advantages were in all probability appreciated by most electrical engineers, but before there could be much extension of the induction motor, it was necessary to satisfy English engineers on one point, and that was, How do we stand in regard to patent rights? It must be confessed that the position has been an unsatisfactory one, and we can hardly accuse the reputed owners of the patents of unduly advertising their rights. There seemed to be insuperable difficulties in the way of obtaining authoritative information as to what were the patents, or to what extent they governed the three-phase motor. On all hands the question was raised, but as no satisfactory reply could be given, manufacturers, for the most part, gave up all idea of entering into the manufacturing of multiphase motors, and it is this difficulty, more than all others, that has retarded their introduction into this country. One of the most definite opinions given on the subject was that of Mr. Rankin Kennedy, which appeared in these columns,* to the effect that:—"There are some good and valid patents concerning the various 'improvements' on polyphase motors, but it is extremely doubtful whether any one, or more of them, can be held as a master patent controlling the whole of the polyphase motor business."

Considering, therefore, the delicacy of the whole question, the announcement that Messrs. Thomas Richardson & Sons, of Hartlepool, in conjunction with Messrs. Brown Boveri, had made arrangements to manufacture multiphase machinery in this country was naturally of considerable interest.

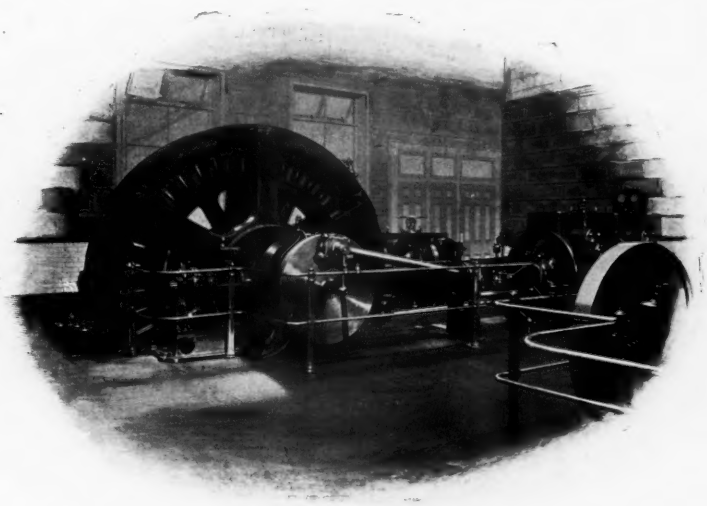
We have recently learned how Messrs. Richardson & Sons came to add so interesting a department to their extensive engineering business, and it will be entertaining to recount how the multiphase motor question was approached by them. Sir Thomas Richardson has long been impressed with the value of electrical driving, and he has for some years been a staunch adherent of the system. In order to obtain a comprehensive knowledge of the various methods of electrical transmission over short distances, Sir Thomas Richardson and Mr. D. B. Morison visited the Continent, and the result of their investigations was to establish in their minds the marked superiority of multiphase methods. When they sought, however, to introduce



General View of Multiphase Generators at Messrs. Richardson & Sons.

* Electrical Review, Vol. 39, p. 496.

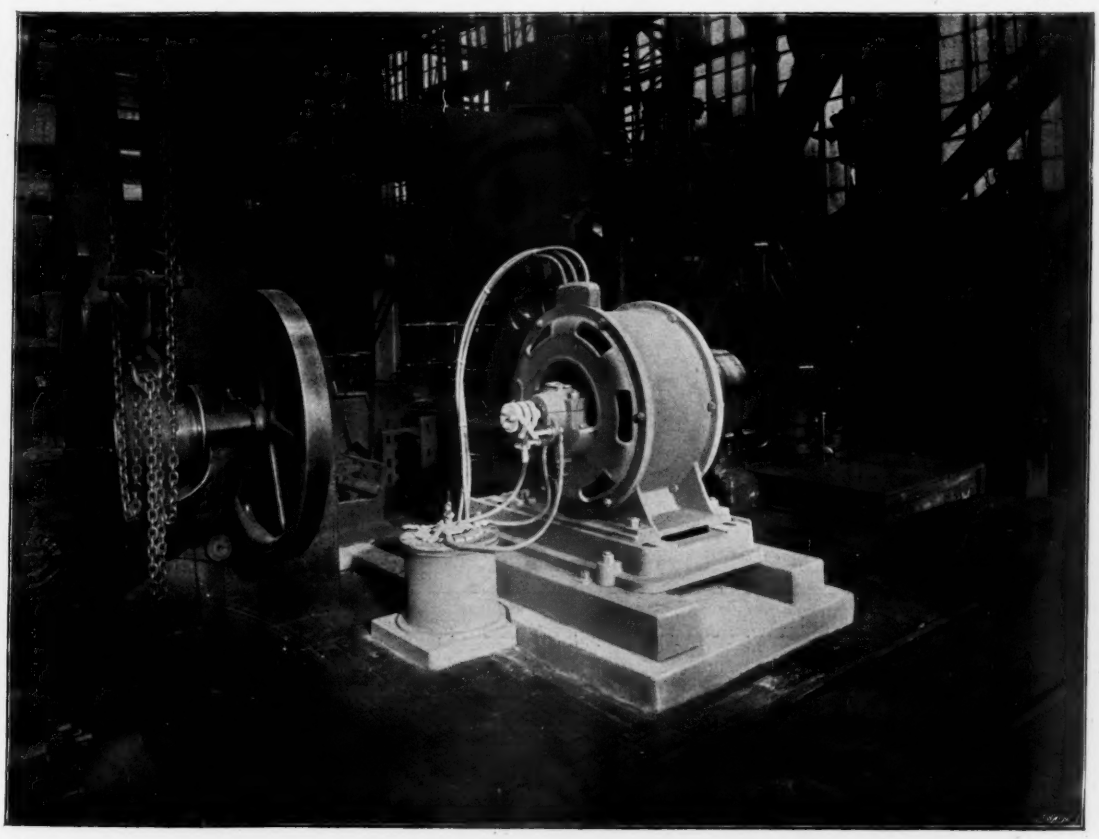
three-phase working into their own works, they were immediately confronted with the patent question; but not to be turned aside by an obstacle of this nature, they sought legal assistance, and went into the whole question of the patent rights for induction motors in this country. The result of their somewhat elaborate investigations was to satisfy themselves that the Tesla patent really covered the ground, and so convinced were they of this fact, that negotiations were immediately commenced with the Tesla Company for a license to use and manufacture multiphase motors. The preliminary negotiations were most unpromising, however, and when pressure was brought to bear on the Tesla Company, the patent rights were transferred to the Westinghouse Company. Difficulties again arose, but ultimately satisfactory arrangements were completed.



Multiphase Generator at Messrs. Richardson & Sons.

Whatever difference of opinion there may be on the legal aspects of the question, Messrs. Richardson & Sons are to be heartily congratulated on arriving at one solution of an apparently intricate problem. They have not only cleared the air of the mystery that surrounded the ownership of the induction motor; they have laid down a plant for multiphase working on a sufficiently large scale to demonstrate the simplicity and economy of the system. It will be admitted, from the illustrations of the generating plant, that Messrs. Richardson & Sons have provided a model station, and for arrangement and soundness of design we do not think that this country has anything superior to show.

Without taking into consideration this latest addition to multiphase systems, we suppose, at the outside, there are not more than four or five in the United Kingdom, and these are only of moderate size. There is a small one at Glasgow of 100 horse-power, and another of about 130 H.P. in Edinburgh, in both of which cases "Brown's" machinery is employed; in addition, there is the one at the Liverpool Grain Warehouses, which was recently described in these

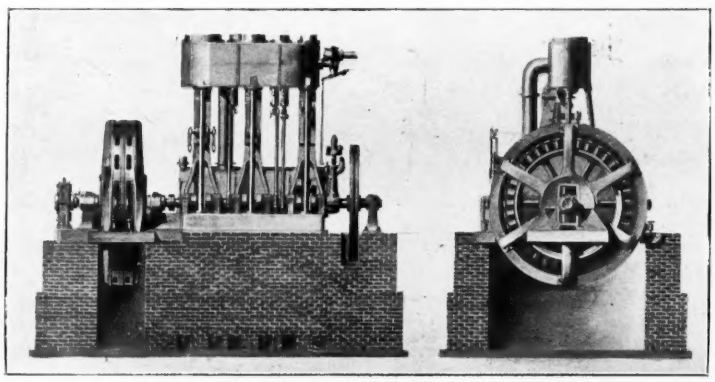


Multiphase Motor Driving Shafting at Messrs. Richardson & Sons.

The position then at the present moment with regard to three-phase patents in this country, and, of course, it must be remembered that the present position has been arrived at without the intervention of the Courts, is that it is necessary to obtain a license from the Westinghouse Company.

columns, and probably there are one or two others on a small scale.

The plant, which has been laid down by Messrs. Richardson and Sons, aggregates about 1,250 H.P. There are at the present moment, as will be seen from the illustration, two large fly-wheel generators driven by horizontal compound engines, and a smaller machine of 80 kw. driven by a single engine, which is intended for night shifts. Each of the fly-wheel generators is capable of absorbing 420 brake H.P., which is the full output of the engines. The generators supply three-phase current to motors placed at different parts of the works. The plant is located in a well-designed building, the interior of which is lined with terra cotta coloured plaster, which helps to give a pleasing appearance to the station. The steam raising plant consists of two marine type boilers, generating steam at 160 lbs.



Messrs. Richardson & Sons' Direct Coupled Vertical Engine and Multiphase Generator.

The fly-wheel generators run at a speed of 125 revolutions, and generate three-phase currents at a tension of 200 volts between each terminal, and at a frequency of about 41 per second.

The rotating part of these machines consist of the fly-wheel of the engines, on the circumference of which are fixed the poles of the field magnet system. The winding of these poles consists of a spiral of copper strip, wound up on edge, the several convolutions of strip being insulated from the neighbouring turns by layers of varnished paper. This rotating field magnet revolves within the fixed armature. The laminated iron core of the armature is securely held in a cast-iron frame, the whole being divided into two parts for convenience and handling. This ring-shaped armature is supported in position on two star shaped cast-iron frames, which in turn are carried centrally on trunnion rings, bolted to the frame of the engines.

The armature, when in position, is thus like a wheel, capable of being rotated round the trunnion ring mentioned above.

The turning moment exercised on the armature by the rotating field magnet when the machine is doing work, is taken up on small bed-plates on the ground level at the outer circumference of the armature.

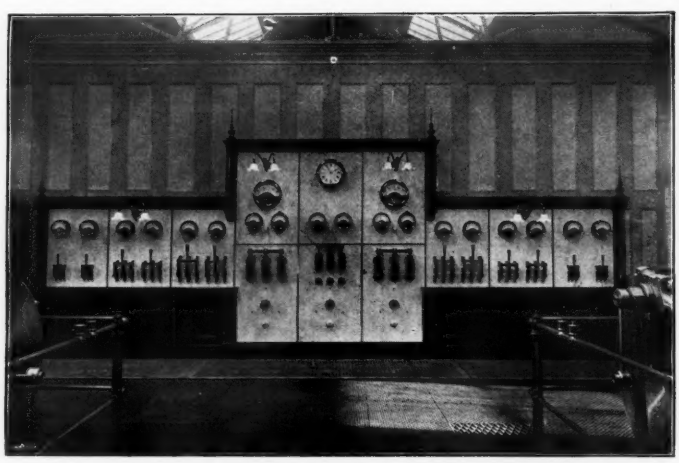
These bed-plates are so arranged that, on loosening the tightening screws (seen on the photograph at the circumference of the armature), part of the bed-plate can be slipped out of its place, which allows the armature to be rotated, there being then sufficient clearance for the screws and their bosses to pass through the embrace of these bed-plates.

The advantages claimed for this mode of construction are firstly, the possibility of carrying the armature absolutely centrally with regard to the rotating part, and secondly, that it allows easy access to any part of the armature for cleaning or possible repair, without making the pit in which the armature is situated so large as would otherwise be required.

The simplicity of the switchboard, as evidenced by the illustration, is one of the most noteworthy features of this plant. It is made up of three larger and six smaller marble panels, the larger ones being for the generators and the smaller ones for the feeders. One great point about the board is that the back is quite open, and access can be obtained to it from the adjoining room. Connections are brought from the dynamos by means of flat strips carried in tunnels, and the strip is continued along the back of the board, the size decreasing as the end of the feeder connections is reached. The fuses are fixed at the back of the board. Each panel carries a three-point switch and a voltmeter and ammeter, large dial ammeters easily read from all parts of the room indicating the total output of the plant. The mains throughout the works are carried in underground tunnels and supported on porcelain insulators.

The synchronising arrangements are simplicity itself, a pair of 200-volt incandescent lamps being used for each machine. No artificial load being used, no difficulty whatever is found in using any combination of the three machines in parallel.

Thirteen motors are installed in the shops; the sum of the powers of these machines is just over 500 H.P., five of them are 65 H.P. machines, the others vary in size down to 10 H.P.



Multiphase Switchboard at Messrs. Richardson & Sons.

A motor of 20 B.H.P. drives the pattern shop, and it is interesting to observe that this motor has repeatedly been tested to double its working load. This motor drives from a floor above the wood-working shop, the motors in all other cases being fixed on the floor and driving upwards. The illustration which we give shows one of the motors driving the whole of one of the engineering shops, thus supplanting an old beam engine, which is situated just behind the motor.

The "Brown" multiphase motor is too well known to need further description. The windings of the fixed part of the motor which are traversed by the main current are carried through tunnels in the laminated iron. These tunnels are insulated with layers of varnished paper, which has been found a very satisfactory insulator for all tensions.

The rotating part of the large motors is also wound with a multiphase winding, the three ends of which are brought out to sliding contact rings on the shaft At starting, a three-branch resistance is inserted between these rings, to regulate the current at starting in the same manner as in a continuous current machine.

As a point in favour of the economies already effected at Messrs. Richardson & Sons by the introduction of the multiphase plant, it is worth noting that it is expected that the

fly-wheel generators will supply power for the whole of the works, which hitherto has necessitated the use of *ten boilers*.

It is very evident that considerable interest is being taken in multiphase transmission, and at the present moment Messrs. Richardson & Sons have orders in hand for multiphase plant equivalent to 1,500 H.P. The type of combined plant which is being recommended is shown in the annexed sketch, and consists of a triple expansion engine of the vertical type, coupled direct to a three-phase generator. We trust that every success will attend the courageous efforts of Messrs. Richardson's to introduce multiphase machinery into this country.

Mr. Charles F. Higgins, formerly chief assistant to Brown, Boveri & Co., is superintending the electrical department at Messrs. Richardsons. It may be mentioned that Mr. Higgins has been intimately concerned in the introduction of multiphase machinery into this country, and has supervised the erection of all the "Brown" multiphase plant including the small plants at Glasgow and Edinburgh. Messrs. Geipel & Lange, of 68, Victoria Street, are the London agents for Messrs. Richardson & Sons.

TWENTY-FIVE YEARS' DEVELOPMENTS IN TELEPHONY.

By J. E. KINGSBURY.

(*Continued from page* 660.)

he gave a popular explanation of the balanced metallic circuit, which I may be permitted to quote:—"Generally the circuit is made by a wire only one way, and is completed by the earth. But it is to be regretted that economical considerations render this necessary, as the extreme delicacy of the telephone makes it susceptible of great disturbance by induced currents. If the earth be used as part of the circuit, there is a liability to a variety of disturbing causes from earth currents; and if there be a powerful dynamo machine in the neighbourhood some extraordinary results may be got. . . If a complete metallic circuit were not too costly, and if the two wires out and home were very close together, or if they were insulated and twisted into a sort of rope, a great deal of this evil effect of induction would be got rid of, and would be got rid of upon a principle that is readily explicable. Suppose the effect of induction from a neighbouring wire is to add to or deduct from that which is going on in the telephone wire. Think of it as you would of a pair of scales. If you have a pair of scales and you put 1 lb. in each scale at the same time, or if you take equal weights out of the two at the same time, you do not disturb the balance. If, therefore, you have two wires of the telephone circuit close together and close to the disturbing influence, that influence acts equally on both wires, and it is as though you put 1 lb. in each scale at the same time, or took out 1 lb. at the same time—that is, nothing is done to disturb the balance, and in that way the difficulty is got rid of."

"Twisted into a sort of rope" is a reference to the important discovery of Professor Hughes for maintaining balanced circuits, but the principle has involved considerable work and ingenuity in being carried into practice, as may be gathered from Mr. Gavey's recent paper at the Institution of Electrical Engineers on twisted wires, and by the researches of the American Bell Telephone Company's Engineers for the equivalent cross system. It must be admitted that the replacing of single wires which has become, or is becoming, necessary by the advance of other branches of electrical work is now possible upon terms which would hitherto have been impossible. Underground circuits, except in the case of the British Post Office or in the Paris sewers, offered very considerable difficulties, and with the material generally used were distinctly detrimental to the transmission of speech. The insulating material then generally used was guttapercha with a high capacity, but Brooks's iron pipe cable with conductors separated by fibrous material, and oil as additional insulation had some vogue, and about the date of Sir Frederick Bramwell's address (1883) there was used by the London and Globe Telephone Company a lead covered cable, the invention of Mr. Patterson, in which aerated paraffin wax was substituted for the liquid oil. With paraffin—the available insulator of lowest capacity—reduced still further to the extent of 15 per cent. by aeration, the conductors were far more suitable for telephonic use. Lead pipe cable did not commend itself very readily to those who had relied upon earlier forms of insulated conductors, but the importance of low capacity grew greater as the lines grew longer and lead covered cables became generally used and for such a period as to demonstrate the reliability of lead pipe. With this confidence in the mechanical envelope and the terminals used, the omission of the insulating material became possible, and such cable was introduced under the name of "dry core" or, as it is now sometimes called, "air space." The first length of this cable used in Europe was laid by the Western Electric Company in 1891 between Liverpool and Birkenhead through the Mersey Tunnel, though it had been in use some few years previously in the United States. To provide for the cables extensive conduits have been required, and these have been constructed of such varied materials as wood, asphalte, terra-cotta, and cement, as well as iron pipes. The most conservative elements in telephone engineering, perhaps, are lead cables and iron pipes. The passenger along Holborn to-day may see three inch iron pipes being laid, into which lead covered cables will be drawn. Forty years ago he might have seen in use the same sized pipes also carrying lead cables for telegraphic use, but there is some difference in the number of wires accommodated. One pipe then carried between 40 and 50, it now carries between 400 and 500.

The temptation to indulge in elaborate statistics of past progress or prophetic visions of future growth is, perhaps happily, checked by the exigencies of space. Whilst 1878 saw the first commercial telephone exchange in the United States, and 1879 in Europe, there is now no town of any importance in the civilised world without the facilities which such an institution affords, not merely for communicating with its own citizens, but with those of distant places. The luxury of to-day is the necessity of to-morrow. Growth there must be. Means and methods may change. In one respect only is there finality. Now that the working of the telephone is familiar it is not unusual to hear some sanguine suggestions to the effect that it may be superseded by some other contrivance, but it may be safely said that the telephone cannot be superseded. Speech is Nature's own method for the communication of thought or intelligence from one mind to another. The telephone carries speech, and for the purposes of conversation places distant persons on an equality with those who may be talking together in the same room. It is therefore not science which stands in the way of the telephone being superseded, but simply the fact that the transmission of intelligence to a distance has been brought through the artificial trammels of codes and signals, and has reached the stage which Nature herself has reached.

THE CONSTRUCTION, LAYING, AND REPAIRING OF SUBMARINE TELEGRAPHS.

By CHARLES BRIGHT, F.R.S.E.

No radical change in the cardinal principles of submarine cable construction has occurred during the period we have here to deal with—or, indeed, since the very beginning. Steady improvements in materials and details are alone the characteristics experienced. Illustrations being excluded from these articles, it is impossible to do more than give a general *résumé*: this we will now proceed with.

In 1872, the conductivity of the copper used in telegraph cables was about 80 per cent., to-day it is over 100; due mainly to the advances made in smelting and refining to a complete state of purification and to greater attention being given to the drawing of the wire; perhaps, also, to more rigid tests being applied.

In the form of the conducting wire a marked improvement was introduced by the late Sir William Siemens in 1874, over the Direct United States Cable. We refer to the "solid strand" conductor—*i.e.*, a stout central wire surrounded by a number of smaller ones—in which the electrical advantages of a single wire are combined with the mechanical features of a strand. Here the gain in conductivity, with a given area of copper, may amount to something like 10 per cent. over that of an ordinary strand, and the corresponding gain in speed is appreciable. Messrs. Siemens Brothers & Co. have since adopted this form of conductor for all the subsequent Atlantic cables, in the design and the construction of which they have been concerned. Moreover, the conductor of the last "Anglo" Atlantic Cable (1894) was made by the Telegraph Construction and Maintenance Company after this pattern; indeed, the above type of conducting wire will probably become universal for all great lengths exceeding, say, a thousand miles.

Unfortunately, the period with which we are concerned is not marked by any corresponding advance in the insulator—rather the reverse, partly owing to gutta-percha being less plentiful, and more generally required for ordinary purposes, as well as on account of severe competition. The improved process of manufacture introduced by the late Mr. Willoughby Smith—whereby the specific inductive capacity with a given substance was reduced from about ·075 to ·055 microfarads—had come into use some two years previous to our starting point. But though no improvement in the quality of the insulator has been secured within the last 25 years, vast progress has taken place in the methods of its application to the copper wire. This has, notably, been brought about by the "G. P." Covering Machine, standing in the name of Mr. Matthew Gray, Patent Specification No. 5,056, of 1879. In the latter device air is excluded, and the gutta-percha drawn between two horizontal rollers in the form of a sheet, to be afterwards forced along to the die by means of an Archimedean screw; the uniform driving of the latter ensures a regular feed to the die-box through which the wire is led. In the early days an ordinary cylinder and piston apparatus was in use as a "G. P." Covering Machine; but much trouble was experienced in core so made, owing to the presence of air, which, when later subjected to the pressure of the sea, would burst through the covering. Hence, the above and other similar devices, designed with the same object during these years. Again, Mr. Ludwig Loeffler, in 1880 (Provisional Specification No. 905), devised a plan for applying the separate coats of gutta-percha at one operation, in what may be called "streams" forced into the die-box at successive points. The main purpose of this device was to obviate the use of Chatterton's compound between coats; here, then, greater heat to ensure sufficient "tackiness" is entailed; also more trouble to produce the required cooling action through what may be considered as the entire thickness in one covering. This multiple-die system has, however, several advantages, and is in general use at the factory of Messrs. Siemens Brothers. A gradual progress is noticeable in the jointing of gutta-percha core, until such perfection has been reached that the joint itself, when performed by the skilled hands of to-day, is as perfect as the rest of the core—besides being completed in sensibly less time than formerly. Somewhat similar advances characterise india-rubber core—made on the lines first suggested by the late Mr. William Hooper—and india-rubber joint manufacture, though the necessary curing still renders it a comparatively lengthy process, and though the application of the rubber is even now performed in much the same manner as originally. Finally, we may say that the result of this gradual progress in the details of the insulation is that faults are nowadays of a relatively rare occurrence.

Let us now turn to the advances made since 1872 in the protective and strengthening parts of our submarine telegraph cable. With the special object of evading the ravages of the teredo and other boring creatures, Mr. Henry Clifford produced, in 1878, a system of surrounding the core with metal tape. According to a previous device—intended for more general purposes including strength—the metallic riband was applied outside the hemp (or jute) serving, but some difficulty had been experienced in laying a tape satisfactorily on so uneven a bed as that afforded by yarns; in fact, an absolutely regular surface was found to be essential. Clifford's "Brass Taping"—in extensive use for the comparatively shallow and warm depths pervaded by borers—was first adopted by the Telegraph Construction Company in the manufacture of a part of the Eastern Extension Company's Penang-Malacca Cable laid in 1879.

Though the metal sheathing for the core is not uncommonly spoken of as brass taping, it is more generally composed of that variety of brass known as Muntz metal, being a compound of copper, zinc, and tin, containing rather more tin and zinc in it than ordinary brass and correspondingly less copper. This mixture is found to afford a remarkable degree of hardness and toughness to a comparatively small weight; moreover, it introduces little or no chemical action, besides being far cheaper than copper. Quite recently phosphor-bronze has been sometimes used for this purpose instead of ordinary brass or Muntz metal. This is with the idea of still further combining the maximum strength with the minimum weight. Again, phosphor-bronze is supposed to be more durable, though certainly dearer at the outset. According to Mr. Clifford's plan, first of all a fine (wet) cotton-tape (about half-inch broad) is applied spirally, with about half overlap by way of bedding and for preservative purposes; then (2) the metal ribbon of same breadth and four inches thick, is laid on with half overlap; and finally (3) a waterproof preservative and protective cotton-tape, rendered so by being previously soaked in stearine (mineral wax), or other resinous compound. These three tapings are each applied alternately with opposite lays, the length of which depends on the width of the tape adopted. This is with a view to more thoroughly covering (upon each side) every overlay of metal tape, for its better preservation and waterproofing. Inasmuch as in a brass-taped cable the tape acts practically as the main "earth," it is undesirable that the inside tape should be "compounded," for fear of making faults. By the Clifford system all these tapes are applied at one operation. The Silvertown Company use wet cotton *threads*, or yarn, as a bedding for the metal riband in place of the calico tape. These threads naturally provide a very soft bed, and are not subject to ravelling; moreover, adapting themselves better to the surface at disposal, they need not be applied with any overlap. Again, threads are said to retain moisture better than tape, and are—for electrical test reasons—thought, therefore, to be better suited. Provided it is properly applied, metal taping is supposed to be a fairly absolute protection against borers; indeed, no cases of trouble have been known to be traceable to this cause with a cable, the core of which is so sheathed. Moreover, it is to some extent effective in preserving the dielectric from decay (by oxidation, evaporation, and the result of alternating wet and dry conditions) in the instance of gutta-percha insulated lines laid in dry soils ashore.* However, in the recent Amazon River Cable (1896), Messrs. Siemens Brothers, to meet similar circumstances, made what was a new departure as regards submarine telegraphy. The core of the shore-end type instead of being brass-taped was covered by a lead tubing, thus rendering it absolutely teredo-tight as well as air-tight. The core was followed by a cotton taping, over which the lead covering was applied and externally compounded. Outside this were two servings of jute of opposite lays, followed by the usual sheathings, &c. For the land line connections in the form of trench cables the

* In multiple conductor cables, metal taping outside each core has been adopted by the Engineer-in-Chief to H. M. Post Office (Mr. W. H. Preece, C.B., F.R.S.) in the 1896 Bacton-Borkum cable. This was, it is believed, with a view to reducing to a minimum the effect of static induction from wire to wire, and also in order to neutralise—by thus introducing *magnetic* induction—the electro-static capacity of each circuit. Previously the multiple cables of this department had only a single brass tape outside the serving of the wormed cores. Substantial benefit in working efficiency is said to have been derived from the above modification.

same plan was adopted for more perfectly obviating the decay which gutta-percha is subject to in dry soil, as already set forth. The trench cable consisted of core, cotton tape, leaden tube, compound and two servings of tarred jute, the proper length of this being previously let into each length of the shore end without any joint or splice.

With regard to the inner serving, we have only to say that, whereas what was described as hemp had been employed for this purpose in early days, jute is invariably adopted now—excepting by the Post Office, who have special conditions to contend with—for, besides being cheaper, it is more durable as a rule. Inasmuch as a closely packed bed for the sheathing wires and protection to the core are the main considerations (rather than tensile strength), everything seems to be in favour of jute for the inner serving. As the result of experience, the inner serving is, nowadays, more closely packed than used to be the case, and smaller yarns are, generally speaking, adopted to meet this end.

As we have before remarked, the submarine telegraph of to-day is practically the same as it was 25 years ago; indeed, there is probably no branch of engineering which has undergone so few changes from the very beginning. Ordinary close-sheathed cables are now universal, as they were in 1872. Some years previous to the latter date a type was in favour for deep water, in which each wire was laid up in hemp (and another in which the iron wires were alternated with hemp), but though having the advantage of a particularly low specific gravity this type was soon found to be utterly lacking in durability, and a return to the original pattern was made. By way of preservation from the oxidising influence of air and water, the sheathing wires of all types of submarine cables are galvanised, as they were almost invariably at the outset. On the other hand, vast strides have been made in the manufacture of homogeneous (hard drawn) iron, so much so that it can be procured with a breaking strain equivalent to 90 tons per square inch, as against some 60 tons in 1872. Indeed, for extreme depths well tempered steel wires are sometimes employed with a tensile strength represented by nearly 100 tons to the square inch. The iron wire is nowadays tested in greater detail than it used to be—that for the main (deep-water) types for tension and elongation, that for the shallow-water types for torsion. In present practice—apart from galvanising and the outer case—each iron wire is either separately "compounded" or separately covered with cotton tape—or both, as in the instance of the last "Anglo" Atlantic (1894), which may be regarded as an excellent prototype of a modern ocean cable.* The former plan probably had its origin in a patent of the late Mr. Willoughby Smith—No. 3,622 of 1878. Perhaps a still better preservative to the sheathing is the latter system—*i.e.*, enveloping each wire in compounded cotton tape. This also has the advantage of rendering the cable more pliable; it is, therefore, less springy and less liable to throw itself into kinks. Again, the taping of each wire, in reducing the specific gravity somewhat, renders this type well suited for great depths. It no doubt originated in an 1870 patent taken out in the names of Messrs. Matthew Gray and Frederick Hawkins, of Silvertown. Here, however, the patentees appear to have had a somewhat different type in mind. The P.O. Wexford cable—quite a heavy type—was the first example in practice about the period at which we commence here. The system did not come into more general use for deep water till comparatively late years. A cable whose wires are individually taped certainly involves a slightly increased initial cost; and this is one of the objections raised by the opponents to taped wires. However—for deep water purposes, at any rate—this increased initial cost is more than repaid on the various counts named, especially that of assigning to the cable greater durability. The latter point may be demonstrated by immersing a length of untaped and taped wire in a vessel containing sea water, or, still better, two specimens of completed cables, the one with taped and the other with untaped wires of the same construction in every other respect. If possible, the bottom of the containing vessel should be lined with a sample of the bottom to be encountered. There are those who assert that this method of enclosing each wire in compounded tape (or of coating each separately with compound) has the effect of disguising the presence of faults brought about during the process of sheathing. No actual instance of this is, however, to hand. Again, it is alleged by some electricians that either of these plans interfere with a proper "earth" connection. Inconvenience has certainly been experienced on this score, but it may be questioned whether it is of sufficient importance to out-weigh the value of taped and compounded wires to an investor in submarine cables.

In the method of laying up the sheathing wires, no important changes have been made except that for all types other than the heaviest, the skeleton frame pattern has by degrees entirely replaced the old disc machine: the result is that the manufacture can be got through much quicker. A notable example may be taken in the Telegraph Construction Company's factory at East Greenwich. In 1872 about 20 miles could be made in the course of a working day (10 hours); now with fewer machines, but of the latest pattern, at least 30 miles are made on the average when a big contract is being carried out. This increased rate of progress may be partly due to the electric welding of the joints in the sheathing wires—a plan, which, at these works, has superseded the ordinary forge weld for several years. It is contended that besides the joints so made being absolutely free from impurities, they save time during "laying up" on account of increased durability; furthermore, they take less time to effect. With reference to cable-making machinery, it should be mentioned that Messrs. Johnson & Phillips have made a special study of this. Of late they have been in the habit of constructing the machine for the heavier class of cables on the same cylindrical cage pattern as those for light types—only, of course, much stronger.

We will now turn to the outer covering. Here, the year 1872 happens to mark the introduction by Messrs. Johnson and Phillips* of a plan for applying Hessian (canvas) tape as an outside preservative covering and binder to the iron sheathing, in place of the hemp yarns previously in vogue. It was claimed that such an outer casing would effect a material saving in cost, with a reduction of at least 20 per cent. in the coiling space required. Moreover, canvas tape is, as a rule, more durable than yarns. It also keeps broken wires better in place, being applied with greater tension. Thirdly, it is rather more equal to resisting the attacks of living submarine organisms. On the other hand, tapes involve a more rigid and less pliable cable, which is an objection from the contractor's point of view as regards general handling up to the time of actual submergence. Again, yarns are found to adhere together more willingly than tapes. They are, in fact, a superior vehicle for the compound, which is better able to percolate between threads. For these reasons—and further owing to the improvement in the durability of jute and hemp yarn—canvas tape is less used nowadays than it was, a return having been made to hemp yarns as well as to jute, let alone the introduction of hemp *cords*. Jute has of late been largely employed for the outer covering. This is partly owing to improvements in its quality and preparation, rendering it much more durable, and more so than ordinary hemp yarns as a rule.† As regards the outer covering, jute is very usually used for the shallow water types of a given cable, and hemp for those which are intended for deep water. To more effectually meet the requirements, and with a view to adding strength to the cable, what

* The "compounding" of each iron wire—sometimes from the residue of gutta-percha—is very usual for types intended for moderate depths, whilst the individual taping is more confined to quite deep-water types.

* The late Mr. W. T. Henley is also said to have taped cables externally at an early date—possibly based on this device.

† As a test of subsequent durability on submergence at the bottom of the sea, Messrs. Siemens Brothers have a practice of keeping different kinds of rope—sometimes laid up into cable—in a tank of salt water, and then examining and testing them in various ways.

are known as hemp *cords* came into use for the outer serving of deep sea types in place of the ordinary three-ply, 10-lbs. per N.M., hemp yarn. This plan was first adopted by the Silvertown Company for their St. Vincent—St. Jago cable of 1884; and they have always adhered to it where extra strength is aimed at in deep sea types. These "cords" are made up of Russian hemp from several strong yarns—very often three—stranded together. They are applied with such a lay as is said to increase the strain which the cable will bear to the extent of one ton, by the full amount of their individual strengths (about 1 cwt.). In any case these cords, in possessing greater strength than the single, double, or treble-ply yarns, certainly have the additional advantage of acting as a more secure binding, thus more effectually checking the unlaying of the wires under strain. This especially applies when a ship is hanging on to the end of a cable in deep water for splicing operations. In the present day a very usual outer covering is one serving of canvas tape followed by a single layer of hemp cords with a coat of compound intervening.

In 1883 Captain Samuel Trott and Mr. F. A. Hamilton strongly urged the claims of a light cable of their device, consisting of several applications of hemp laid up opposite ways round the core. They read a paper on the subject at the then Society of Telegraph Engineers, which produced rather a warm discussion regarding the unlaying of an iron-sheathed cable during the various operations entailed. In 1889, about 50 miles of the Trott and Hamilton cable was inserted in the deep waters of the 1869 Atlantic. Again, in 1892, a similar length was inserted—also in deep water. Both of these remained in circuit for some three or four years. Since then the almost classic question of light cables (innocent of iron) has remained dormant.* —R.I.P.

We now come to the laying of our cables at the bottom of the sea. In 1872 there were six telegraph ships—including the "Great Eastern," which was last employed for cable work in the laying of the 1874 "Anglo" Atlantic; to-day there are 42, of different denominations, doing service in various parts of the world, including a "four-master" now being built for the Telegraph Construction Company, which will be capable of carrying even more cable than ever the "Great Eastern" was. The, at present, largest telegraph ship afloat, ss. "Silvertown," bought by the India-rubber Company in 1881, was launched (as the "Hooper") in 1873. She has a displacement of 4,935 tons. Messrs. Siemens Brothers' ss. "Faraday" (launched the following year) comes next with a tonnage of 4,917. The French repairing steamer, "Ampére," 300 tons, represents the other extreme, as regards size. In the apparatus for paying out and picking up cables, the improvements of the last 25 years are of a detailed character: the general principle of the machines are the same as before. These consist mainly in (1) the substitution of steel for iron, and the consequent lightening of the gear; (2) the combination of a drum, brake, and spur wheel in one piece instead of three, as formerly; (3) duplicate, or even triplicate, drums, with independent engines for the bow gear, so as to permit of dealing with two ends at one and the same time; (4) improved methods of carrying the bow sheaves; (5) brake adjustment by means of worm and screw gear. Improvements of this character have been incorporated in all the many comparatively recent repairing vessels of the "Eastern" and the other cable-owning companies fitted out by Messrs. Johnson & Phillips. This latter firm is, indeed, peculiarly identified with this class of work, and they have probably done more in the above direction than anyone to further the requirements of easy, efficient, and safe cable operations during the years we have to consider here. An important novelty in cable-laying connected with this period is the slack measuring apparatus (by an auxiliary steel wire) of Messrs. Siemens Brothers. Its principle was first publicly described by Werner von Siemens before the Berlin Academy of Sciences in 1874. In that year also, Mr. F. C. Webb, M.Inst.C.E., devised a method of landing shore ends by floating casks at intervals. This was afterwards improved on by Mr. R. K. Gray, M.Inst.C.E., by balloon-buoys. Under certain conditions, the method is an extremely useful substitute for other previously known systems. The importance of a more complete survey previous to laying a cable has lately thrust itself on the minds alike of contractor and engineer. Thus, where soundings were taken at 100 mile intervals in early days, one observation in every 10 miles is often the order of the day now.* In conformity with the appreciation for more thorough surveys, the apparatus for carrying them out has been considerably extended and improved on during this period. About two years after the "Lalla Roohk" experiments of 1872, Lord Kelvin, F.R.S. (then Sir William Thomson), read a paper describing his pianoforte wire deep sea sounding apparatus as a substitute for the ponderous, bulky, and hemp line. This invention was at once taken up for telegraph ships; it rendered practicable that which before was almost out of the question. The apparatus has since been improved on by various gentlemen, and in the present day we have several excellent machines for this purpose, designed by Messrs. Johnson & Phillips, Mr. F. R. Lucas, and the Silvertown Company, who took the matter up warmly from the commencement. The supply of sounding tubes with detachable weights is also plentiful, not to mention suitable (deep sea) thermometers, &c. With regard to repairs, it can only be said that the various grapnel devices introduced since 1872 are legion. These are mainly modifications, in one form or another, of the cutting and holding grapnel first suggested by Mr. Latimer Clark, F.R.S., and also by the late Mr. Frank Lambert. They emanate from Professor Andrew Jamieson, F.R.S.E., Mr. F. R. Lucas, Mr. Claude Johnson, Mr. H. Benest, Mr. Edward Stallibrass, and others. And here we think our space has become exhausted.

* Though hemp is less subject to decay when unaccompanied by iron, it seems to deteriorate rapidly when at the bottom of the sea. So much so that, notwithstanding the low specific gravity, after a comparatively short time a hempen cable has not sufficient strength to support itself when picked up—even if composed of a material entailing greater initial cost than an ordinary iron-sheathed cable.

* For instance, preparatory to laying a cable between Spain and the Canary Islands in 1883, the Silvertown Company's T.SS. "Dacia" and "International" took no less than 552 soundings at the last-named distances on two separate zig-zag routes (starting from Cadiz), in order to determine the best line, and for planning out the "slack" to be paid out at each point.

TWENTY-FIVE YEARS OF EXPERIMENT IN PHYSICS.

By ROLLO APPLEYARD.

"Ask not the latest news of the last miracle . . . .
Ask what most helps when known, thou son of Anchitus!"

To write the history of the historical Present, to count its trophies, to number its heroes, is to tell the story of a mighty host whose glories stretch beyond our vision—even beyond our lives. The task fails us. But, here and there, the gleam of arms gives to the picture character and form. It is a mere impression—Nature uniting what is true to what is beautiful. We are adrift on the Unknown, and Experiment is our enchanted coracle:—

"It seems to float ever, for ever,
Upon that many-winding river,
Between mountains, woods, abysses,
A paradise of wildernesses."

We will take our first bearings from the territory of the astronomers. Stellar Physics, during the past 25 years, has seen many developments, both in the administration of observatories and in the research work of laboratories. The chromosphere of the sun has been examined visually and photographically. Lockyer has introduced the photographic method in comparing solar and metallic spectra, and has added many "solar" elements to those

of Kirchhoff, Ångström and Thalén. Rowland has examined the solar spectrum with a concave "grating," and has completed a table of spectral lines with their origins. Janssen has advanced our knowledge of telluric lines. The temperature of the sun has recently been computed by Wilson and Gray to be 8,000° C. Sun-spots have been studied at South Kensington and at Stoneyhurst; they have been shown to have a periodicity of 11 years. Their occurrence is now attributed to the "dissociation" of solar elements.

At the beginning of our period, Maddox, Bolton, and Abney were at work at dry-plate photography; Abney went so far as to photograph a kettle of hot water by its own "dark" radiant energy. Stellar photography was the theme of Warren de la Rue, as President of the British Association in 1872. To-day, 18 observatories are engaged in completing by this process an International chart of the heavens.

Twenty-five years ago, the Observatory at Kew had just come into the hands of the Royal Society. There, under the superintendence of Chree, much progress has been made in "pendulum" and "temperature" observations, in anemometry, cloud measurement, and atmospheric electricity. In magnetic work, Kew has been the "base" station for Rücker and Thorpe's surveys, and here the tendency to abnormal increase of horizontal magnetic-force on "quiet" days has been discovered. The duty of standardising clinical thermometers and other instruments is now being shared by the Bureau International at Sevres, and by the renowned "Reichsanstalt" at Charlottenburg, but our English observatories have still an increasing amount of this important work in hand. Even as we write, the history of astronomical physics is being made. The great object-glass of the "Yerkes" telescope at Chicago has just been turned skyward, with 40 inches clear "aperture," and a light-gathering power 40,000 times that of the human eye.

From their "base" at Kew, Rücker and Thorpe set out to measure the magnetic forces of the United Kingdom, and they took readings in 867 places. No other country of the same size has had the magnetic elements surveyed in such detail. They were the first to map, for a large area, the lines towards or from which the local disturbing forces urge the north pole of the needle. Rücker has used the results of this survey to calculate the line-integral of the magnetic forces round our coast; he has thus proved that no currents of appreciable magnitude flow from earth to air, or from air to earth, in this part of the world.

In general Physics, progress is seen along two definite lines—(1) The determination of "constants," and (2) The observation of new phenomena. Before proceeding to the sensational discoveries that have characterised this great little age, it may be well to mention some examples of the sober, earnest, work of class (1).

The determination of "constants" is the most important part of the administrative business of the realm of Physics. For the period we are considering, it is associated with a list of names beginning with Glazebrook, Helmholtz, Kohlrausch, Michelson, Rayleigh, Rowland, and Stokes—there is little need to catalogue them here, let us rather consider a few examples, isolated, characteristic, and dissimilar, of the *kind* of work these men or their fellows have done, the *results* they have obtained, and the *precision* towards which they have laboured.

Since the year 1888, Callendar and E. H. Griffiths have perfected a system of thermometry depending upon the change in electrical resistance of platinum wire with change of temperature. To do this, it was necessary to examine the electrical qualities of platinum with most rigorous care, and afterwards to establish the relation between the scale of the platinum instrument and the scale of the air thermometer. Then, to increase the possibilities of the system, an elaborate series of tests was made on the boiling point of sulphur, thus providing a thermometric datum for high temperatures. As a result, they have given to the world a system of thermometry whereby temperatures throughout the whole range of ordinary work can be determined at all points of the scale with accuracy that limits all errors to within one-thousandth of a centigrade degree. Already this platinum thermometer has proved its worth. By its aid, E. H. Griffiths has measured the mechanical equivalent of heat in terms of the electrical units. His value for J has lately received strong confirmation from the work of Schuster and Gannon, but it differs somewhat from the results of Rowland. This difference will probably disappear when the electrochemical equivalent of silver has been redetermined. By an elaborate investigation of the specific heat of aniline, and the latent heat of water, he has given us a basis for a rational thermal unit—a new *calorie*, free from the old ambiguity. This work has been done at Cambridge, and to Cambridge we look for still greater things. The enlargement of the Cavendish laboratory and the encouragement given there to the "Advanced Students'" scheme, points to prospective activity.

Or, again, let us turn to the fine work done by the Ramsay school. In association with Sydney Young, Ramsay has applied himself to the measurement of the relations of temperature, pressure, and volume of vapours and liquids. They have, as an outcome, discovered the law that

$$p = bt - a$$

i.e., that pressure is a linear function of the temperature of a liquid or gas, at constant volume.

Recently, in conjunction with J. Rose-Innes, Ramsay has shown that a similar law holds for adiabatic elasticity, viz.:—

$$E = gt - h$$

i.e., the rise in adiabatic elasticity is a linear function of temperature only, and is independent of volume.

Next, together with John Shields, he has shown that the molecules of a liquid are, as a rule, simple; but that some liquids form complex molecular groupings; *e.g.*, water has not the simple formula H_2O, but is probably $(H_2O)_3$, or it may be $(H_2O)_4$. This is deduced from the capillary rise of liquids in narrow tubes.

He defines the "molecular surface-energy" of a liquid as the energy expended when increasing by unity a surface on which equal numbers of molecules are spread. If the starting point be, for each substance, its critical temperature, and temperature be read downwards, the variation of this energy with temperature is a linear function of the temperature. Thus, approximately at 100° below the critical temperature of ether, its molecular surface-energy is equal to that of, say, benzene, also measured at 100° below *its* critical temperature. And the rate of variation with temperature, under the above conditions, is the same for all non-associating liquids, just as the variation of the volume-energy is the same for all gases at temperatures equally above absolute zero. And, just as there are gases which, on account of dissociation, have a more rapid expansion with increase of temperature than have normal gases, so there are liquids which alter their molecular surface-energy with fall of temperature more rapidly than the great majority of others. It is further to be presumed that the former liquids are associated molecularly, and that the rapid alteration of their molecular surface-energy is due to dissociation when they are heated. The researches on argon and helium present many physical novelties, particularly in regard to the low refractive index of helium, noticed by Rayleigh, and its high electrical conductivity, discovered by Collie and Ramsay.

The physical properties of alloys have been closely investigated in our day, by Roberts Austen. In the "Seventies," he gave his attention to the phenomena attending the solidification of alloys of silver and copper. During the past 10 years he has tried to measure the molecular movements of solid metals. He finds that the constitution of metallic alloys, such for instance as those of carbon and iron, closely resembles that of saline solutions. He also proves that metals, like elements, have allotropic forms. In 1896, he demonstrated that metallic "diffusion," as measured in liquid and *solid* metals at high and low temperatures, follows regular laws, just as in the case of saline solutions;

this is a most valuable generalisation. That beautiful gold-aluminium alloy, $AuAl_2$, is his discovery; to us this substance is specially interesting as being a definite chemical compound, derived from the realm of experimental Physics. Roberts Austen has also attempted to trace the numerical relation between the tenacity of mixed metals and the "atomic volumes" of their constituent elements. The experiment by which he demonstrates the weakening effect of small traces of lead in gold is a striking instance of the evil part that can be played by impurities in metals.

Meanwhile, the accurate numerical measurement of next-to-nothing, has occupied physicists with most useful work. Reinold and Rücker have proved that the surface-tension of a soap-film is a minimum for some thickness between 10 and 100 micro-millimetres, (10^{-7} c.m.), and that it afterwards increases as the thickness diminishes. They have further proved that the electrical conductivity of soap films increases as the thickness diminishes, but that this phenomenon becomes less and less marked if increasing quantities of NO_2 Ko or SO_2 Nao_2 are dissolved in the solution. There is evidence of discontinuity in the law of change of conductivity with thickness at a thickness of 100×10^{-7}c.m. These results go far to show that the "radius of molecular actions" is of the order 50×10^{-7} c.m.—an important confirmation of Quincke's work on this subject.

The experimental investigations by Rayleigh, Ewing, and Fleming, on Magnetism, are being dealt with by a master hand elsewhere in this number of the *Electrical Review*. Fleming, however, at this moment has particular claims to our attention *here*, for in the annals of experimental Physics it must be remembered that he was the first to suggest an Electrical Standardising Laboratory for the Board of Trade. This suggestion has now been realised. In conjunction with Dewar, Fleming has studied the properties of matter at low temperatures. They have shown that at the absolute zero of temperature all *pure* metals would have no electrical resistance. They have demonstrated that the thermo-electric lines are not straight throughout the whole range of temperature, coldwards. Dielectric constants, the permeability of liquid oxygen and liquid air, and the electrical qualities of bismuth, have also come under their notice.

There is no lack of diversity in the scope of experimental Physics. By ingenious models a great deal has been done to increase our knowledge of the constitution of matter. During our period, theory and experiment have greatly helped towards the elucidation of the internal structure of crystals. On the Continent Sohnke, Hessel, Fedorow, and Schönflies have classified the various types and possible symmetrical arrangements of repeated regular systems; and, in England, important generalisations have been made by William Barlow with regard to the homogeneity of structures and its mechanical cause. The Royal Society of Dublin will shortly publish *in extenso* that wonderful paper on this subject presented by Barlow last March to the Physical Society of London—it is a recondite investigation of the highest order.

The following is a brief statement of Barlow's generalisation:—A homogeneous structure is one every point within which, if we regard the structure as without boundaries, has corresponding to it an infinitude of other points whose situations in the structure are precisely similar, so that all of the infinite number of geometrical point-systems respectively obtained by taking all similarly situated points, are regular infinite point-systems defined by Sohnke as systems of points such that the arrangement about any one of these points of the rest of the points of the system is the same as it is about any other of them. Starting with this definition he has investigated all the 230 possible types of structures which fulfil it, and has shown that they all fall into the 32 classes of the crystallographer.

In passing from the first to the second class of experimental Physics we traverse a field of transitional character, where researches and discovery meet us at every point. Here, for instance, we come upon the wonderful work of C. V. Boys, characterised by its extraordinary diversity, delicacy, and precision. His mechanical "integraters" were described in 1881 and 1882, and his radio-micrometer was given to us in 1887. In the playground of science he has blown bubbles, while Perry has spun peg-tops. He has drawn quartz into fibres fine as the hair of a hair, and has hung worlds on them. He has photographed bullets in their flight; and, in another transcendental research, he has weighed the earth. Moreover, he has determined the density of our "local habitation" with such precision that we are now certain that the mean value of the earth's density is 5·5270, with no reasonable chance of an error exceeding 1 in 1,000. These figures have quite lately been confirmed by Braun, working independently in Bohemia.

It is characteristic of this quarter of a century that women have sought admission to the *camaraderie* of physicists. Mrs. Sidgwick did good service in 1883, in determining the specific resistance of mercury by the method of Lorenz, and she aided in the "B. A. Ohm" experiments of 1884, as well as in the standardising of tuning-forks. Miss Klassen did similar service in the measurement of the magnetic qualities of iron. And Miss Dorothy Marshall, in 1896, investigated the latent heat of evaporation of benzine. Mrs. W. E. Ayrton has devoted minute attention to the phenomena of the electric arc. Then too, philosophers have had before them the experimental work of Miss Marie Corelli, on *Atoms*, and have given no little thought to it.

We have now to glance cursorily at the Physics of our second category: "The observation of new phenomena." It is here that we find the fairest evidences of Nature's good-nature. By general consent, it is agreed that the greatest developments have been Hertz's experimental verification of Maxwell's electro-magnetic theories, and the Lenard-Rontgen work on X rays. Second in probable importance is the Crookes-Osborne Reynolds development of our knowledge of the molecular movements in rare gases. Hertz commenced his important researches in 1879, in an attempt to establish experimentally the relation between electro-magnetic forces and the dielectric polarisation of insulators. This was the task set to him by von Helmholtz. In 1883, G. F. Fitzgerald, of Dublin, described a method of producing electro-magnetic disturbances of comparatively short wave-length in wires; and he succeeded in demonstrating that waves as short as two metres can be obtained by utilising the alternating currents that arise when an accumulator is suddenly discharged through a small resistance. Oliver Lodge, in 1888, came very near to the experimental proof of electro-magnetic "waves" and "surgings" in an "insulated bar of metal induced by Maxwell's and Heaviside's electro-magnetic waves." This was *pre*-Hertzian, or perhaps *with* Hertz, but Hertz went much further.

In 1886, Hertz discovered that electrical oscillations in conductors, in the neighbourhood of spark-gap discharges, are regular, and capable of measurement. He next studied the reciprocal action of simultaneous sparks, and he soon found that he was dealing with something akin to ultra-violet light. Electricity was fast annexing optics. By analogy and experiment he was led to discover the finite velocity and rectilinear propagation of electro-magnetic radiations. Then, certain effects due to the walls of his laboratory made him appreciate the "reflection of the waves," and there soon followed "refraction" and "polarisation."

Allied to these phenomena are the actions of light in bringing about discharges of negative electricity. Ebert and Wiedemann are associated with this investigation. In 1889, Oliver Lodge and Howard succeeded in showing the refraction and concentration of electric rays by means of large lenses; and Langley's "bolometer" was used for detecting them, by Rubens and Ritter. Here were all the elements for a crude system of wireless signalling.

In a paper read before the Académie des Sciences, November 24th, 1890, Branly described his famous discovery of "the variation of conductivity under various electrical influences." He used metallic filings with or without a liquid insulating-substance, and he

observed that the effect of Hertz-waves was suddenly to unite the particles into a continuous conductor, even at 20 metres from the radiator. Oliver Lodge has called this apparatus a "coherer," and under that name it has played an important part in the development of wireless telegraphy.

Meanwhile, some very curious results in photo-electricity were being obtained by Minchin; but that is another story, and we must go back several years. In 1873 the sensitiveness of selenium to light, that is to say, its change of electrical *resistance* on exposure, was observed by Willoughby Smith. Börnstein examined other substances, and the phenomenon was developed into the photophone by Graham Bell in 1880. This instrument was modified by Tyndall and by Rayleigh, by the substitution of absorbent vapours for the metallic plate; and Shelford Bidwell made a careful study of the whole question. To Minchin belongs the discovery that certain selenium and other cells engender *electro-motive force* when exposed to light, and also that this actinic sensitiveness is affected by Hertz waves. In the detection and measurement of stellar radiation, his seleno-aluminium cell is more sensitive than the radio-micrometer of Vernon Boys, and by means of such cells he has given us comparative estimations of the light, or radiant energy, of important stars and planets.

The discovery by Crookes, in 1877, of the radiometer led to a series of brilliant researches into the nature of high vacua, and of radiant matter. Six years ago, Nikola Tesla, Campbell Swinton, and others, were making exhaustive studies of various forms of electric discharge from induction-coils traversed by very rapidly alternating currents. Their results were magnificent—even wonderful—but their progress and fashion received a sudden check one day last year, when Rontgen's work was telegraphed to the world. In 1896 we were startled by "one of the most sensational triumphs of the age." Rontgen announced that he had found that, under certain conditions of electrification, a Crooke's tube emitted invisible rays that could permeate certain opaque substances, and produce photographic results behind the obstacles. He found the rays to be incapable either of refraction or of reflection in the true sense. Then Hertz observed that so-called "Kathode" rays were able to pass through aluminium, and this led his pupil Lenard to fit up a Crooke's tube with a small window of aluminium. Thus began a new and vigorous school of Physics. In England, Campbell Swinton was the first to confirm Rontgen's discovery of X rays. Silvanus Thompson gave a delightful historical account of this famous discovery and its consequences, in a lecture on "Electric Shadows and Luminescence" at the Royal Institution, last year.

As "the old order changeth," the apparatus of the laboratory disappears, unnoticed, and sadly. Where now are those old-time cylinder-machines with their gay trappings of silk and leather, with the lavish vermilion of their varnish, and the beautiful glitter of their prime-conductors? The *Electrical Review* thought highly of them in 1872—they had academical value, classical interest; but, like much of the original apparatus of "that great and good man Faraday," they are pushed back upon the shelves with the things of Tyndall, or are cut up and modernised beyond recognition. The Wimshurst machine, perfected in 1882, is responsible for some of this innocent neglect. In its latest form, it is doing good service in connection with X-ray photography, where it often replaces the induction-coil.

Far away there on the borderland between Chemistry and Physics we see the records of Lippmann and Weber, Ives and Joly, in colour photography, utilising the theory of colour vision. We see also a strange thing called "Osmotics," and beneath it the names of Van't Hoff and Arrhenius. These are the signs of the times. Methods for determining the molecular weights of chemical substances in the solid and even in the liquid state, are being perfected, and mathematical methods of discussing the phenomena of chemical change in solution are being developed—apart from the question as to the validity of the ionic hypothesis. The names of Armstrong, Pickering, and Oliver Lodge must be associated with this movement. Important work has been done in chemical physics by Brereton Baker in studying the effect of moisture upon certain substances, *e.g.*, carbon, sulphur, phosphorus, &c. He finds that these can be heated in an atmosphere of oxygen without undergoing visible combustion, and he concludes that certain gases do not combine to form new compounds when dry. For instance, dry ammonia and hydrogen enclosed together in a gas jar, do not unite to form a chemical mixture, but the admission of a little moisture at once determines the change.

While this article is going to press, Continental Europe is doing honour to a great and munificent physicist—Hughes, who in 1878 generously gave the microphone as a free gift to the world, is being installed an "Officer of the Order of His Majesty, King of Belgium." It is the ninth country that has recognised his labours. He invented the induction-balance in 1879, and he supplied the remedy for "cross talk" in telephone wires—*i.e.*, the system of twisted twin wires—in the same year. The microphone is only one of a series of discoveries connected with the names of Edison, Tainter, Chichester Bell, Dolbear and Graham Bell. From the laboratory these things have passed into public service, and will no doubt be described in this number of the *Electrical Review* under the heading of "Instruments."

In acoustical Physics, experiment throughout this last quarter of a century is everywhere associated with the name of Koenig of Paris. He has shown that "beat-tones" have the exact pitch due to the frequency of the "beats" themselves, that they "interfere" and give secondary beats, and that the same number of beats always gives the same beat-tone, irrespective of the interval between the primaries. In England his discoveries and researches have been, as it were, "set to music" by Silvanus Thompson. Helmholtz, Koenig, Stokes and Rayleigh, have advanced our knowledge as to the nature of musical "quality," and the causes of consonance and dissonance. Koenig tried to demonstrate that *both* kinds of combinational tones are merely "beat" tones of the primes or upper partials. In 1895, Rücker and Edser proved, however, that "difference" and "summation" tones have an objective existence. They have thus saved a position of Helmholtz that had been sharply assailed. An experiment of Hasehus, bearing on the refraction of sound, deserves notice. He built a large plano-convex lens of wire-netting, filled with fragments of sponge. The hampering of the sound-waves in their passage through these materials brings about a change of flexure, and causes convergence to a focus. The velocity of loud sounds has been studied experimentally by Jaques; in 1879 he proved that they travel faster than those of medium intensity. Rayleigh has examined sensitive flames, membranes, the nature and amplitude of waves, and the properties of jets. The phenomena of liquid jets are being closely studied by Chichester Bell, they were a favourite theme of Tyndall. In 1874, Osborne Reynolds investigated the alteration in the shape of wave-fronts as dependent upon wind and weather. *With* the wind the intensity is found to be as great near the surface of the ground as it is anywhere. But *against* the wind, the intensity is less on the ground than at some distance above. In 1881, Bosanquet proved that "beats" of mistuned consonances are always on the lower of the two notes concerned, and the limits to which they can be followed diminishes as the pitch rises.

Precision, then, and closer acquaintance with, and better understanding of Nature, are the recorded gains to Physics during this 25 years of experiment. The refractometer of Michelson, and the concave "grating" of Rowland, are tools with which an angel might survey a route for a sunbeam. The phenomena associated with Hertz, Crookes, and Rontgen are to stand as traditions for our remembrance at the millenium. And for their courage, physicists have from time to time received encouragement. In 1894, Sir Henry Thomson generously offered £5,000 to provide a photographic telescope for the National Observatory at Greenwich; and Mr. Ludwig Mond with like, and we hope with what will prove *exemplary* munificence, added

the noble gift of a new research laboratory for London. Moreover, the future of the literature of Physics is well assured. At the instance of the Royal Society, an International Conference held in July last year, resolved to prepare, by International co-operation, complete subject-indexes of the records of science. The work is to commence in 1900. London is to be the head and centre, English the official language.

TWENTY-FIVE YEARS OF ELECTRIC TRACTION.

By PHILIP DAWSON.

To many of us who have only seen the commercial development of electric traction in the United Kingdom within the last few years, it may hardly seem credible that 25 years ago electric traction was thought of; and, in fact, that it was in this country nearly 60 years ago that Robert Davidson ran what may be considered the first electric car.

The early motors, however, were all built on the principle of a magnet attracting an armature. The modern motor practically dates back 25 years, or to the year 1873, when Messrs. Hippolyte Fontaine and Breguet demonstrated at the Vienna Exhibition the reversibility of the dynamo. It was not till 1879 that the first practical electric railway was laid down at the Berlin Exhibition by Messrs. Siemens & Halske, who deserve great credit for their pioneer work in this direction. The first commercial line built along a city road was by Messrs. Siemens & Halske at Lichterfelde, near Berlin, in 1881. In the following two years, England took up electric traction, Mr. Magnus Volk building his well-known little Brighton Line, which is still operated most successfully; Messrs. Siemens Brothers equipping a line at Portrush, Messrs. Mather & Platt putting in the well-known Bessbrook-Newry plant, and Mr. Holroyd Smith building the first conduit road in Europe at Blackpool.

Up till this time England had taken her place among the pioneers of this new and successful system of traction. All the experiments had proved the numerous advantages of electricity, but notwithstanding this, and though she had gone so far, England stopped.

The United States, with a vast, undeveloped country, great distances, and sparse population, had been looking for years for some improved system of traction, which would present all the advantages of the horse tramway, as regards single cars following at short intervals, and have all the comforts which could at that time only be procured on steam roads having roomy and well-lighted speedy trains.

America was the original home of the horse tramway. Being a new country and with very few proper roads, it was found much easier to simply lay down rails instead of completely constructing a roadway. It is therefore quite natural that the Americans with a large mileage of tracks laid down should be on the look-out for an improved system of haulage. In 1873 what we now know as the cable system was brought out by Halliday in San Francisco and was at once taken hold of by the enterprising street railway companies. The cable system had, however, several grave disadvantages, amongst which may be mentioned the very heavy initial expense of building the lines, their very low efficiency, and the fact that a slight injury to the cable would stop the whole system, sometimes for days. Naturally, therefore, the new electric system found supporters in the States, and between 1880 and 1884 the Bentley-Knight, Sprague, Daft, Van Depoele and other Companies, were actively engaged in developing and perfecting the details of a practically commercial system of electric traction. Several trial roads were laid in various cities of the United States, amongst which may be mentioned Cleveland, Woonsocket, and Allegheny, equipped by the Bentley-Knight Company, and Richmond by the Sprague Company. Electric traction as a recognised commercial success dates back however only some 10 years. The adoption of this system by the well-known West End Street Railway Company, of Boston, in 1888, established its economic value. Under the energetic management of Mr. Henry M. Whitney, its late President, every known method of mechanical traction was examined and tested to the fullest extent, regardless of the expense incurred by so elaborate an investigation. The supporters of accumulator traction and of systems employing sub-surface conductors, were given every opportunity to exhibit their practical value on the Boston lines under conditions of actual street railway service. Many thousands of pounds were spent on experimentation by the company, but no system successfully stood the test of commercial operation except the trolley wire. In 1888 and 1889 Boston was the Mecca of every inventor, promoter, and company interested in traction improvements, and all were given a free hand and a fair field. It is improbable that so extraordinary a competition will ever again be witnessed, and no company of less financial strength, or with a more narrow-minded board of directors and executive, could have brought the contest to a successful issue. The prize offered was a grand one, for the decision of the West End Street Railway Company carried with it not only the extensive contracts for its own re-equipment, but the certainty that the system approved by it would be accepted as conclusively superior by the great majority of the tramways in the United States.

Within the first six months of the Boston trials, accumulator cars and conduit-contained conductors were hopelessly out of the race. The trolley wire and wheel had demonstrated an overwhelming superiority. The new system of mechanical traction was accepted throughout America. From this time dates the general adoption of the overhead system throughout America. Thus up till the year 1890 out of a total of 9,000 street railways in America 2,900 were electrically equipped, and at the present moment, or more correctly, at the beginning of this year, out of the total street railway mileage in the United States which aggregates some 17,000 miles, nearly 88 per cent. are operated by electricity, about 3½ per cent. by cable, and the rest by horses, steam and various motive powers.

The commercial success of electric traction in Europe and the enormous development of the overhead system dates back to the year 1891, when the Halle Tramways in Germany were equipped on the overhead system. At the present moment there are nearly 2,000 miles of electric tramways in Europe, of which nearly a thousand are to be found in Germany alone. England, till quite recently, has had no electric tramways to speak of, but there are hopes that she has now got over her lethargic state and will go in for electric traction with a will.

After having been practically the first in the field as regards electric traction for nearly 12 years, England rested on her oars without even making an attempt to find out what was being done in America and on the Continent of Europe, or to profit by the experience of others.

The American manufacturers soon realised the fact that England would shortly be a fine field, and they therefore took every conceivable trouble to educate tramway companies, engineers and corporations, and with such success that now when at last we have overcome the bugbear of æsthetic objections, and when nearly all tramway companies and corporations are going in at once for electrifying their whole systems, there is not one English manufacturer who is able to compete in price or quality with American made goods.

No corporation or tramway company can possibly afford to put in experimental work, or to allow contractors who have not done good work before, to gain their experience at the expense of tramway owners or those who are going to work the line and wish to make it a financial success.

As has been often pointed out, direct driving of generators was first started and put in practice in this country. In the early days of electric traction in America, when the designing of railway generators or engines capable of driving them was not understood sufficiently well, breakdowns were numerous in the station, and consequently, in order to avoid any possible stoppage of the cars, it was necessary to subdivide the units as much as possible, and to have arrangements whereby if necessary any one engine could drive any one generator, and hence the complicated system of countershafting and belt and rope driving. As experience was gained this factor of uncertainty disappeared, and consequently at the present moment both engineers and manufacturers are at one that direct driving is the proper thing for all sizes and for all purposes. For railway purposes direct driving is the proper thing, but considerations entering into the design of railway generators have made it necessary in the case of larger units to use comparatively slow-speed machines, and it is an undoubted fact that although the initial capital expenditure will be much heavier in the case of a slow-speed than in a high-speed engine, the maintenance of both engine and dynamo, in the former case, are much less and fully make up for the extra initial expenditure. In this case again we see how eager to adopt improvements the Americans are. They learnt from us the advantages of direct driving and they have been improving upon it ever since, and at the present moment some of the finest and largest direct driven plant is to be found in America, whereas nearly all the traction plants which have been put in by English firms are rope or belt driven.

We in this country are certainly much more stringent in our requirements, and when we do put in stations or lines they are solidly built and above reproach in every way. It is an undoubted fact that both as regards the solidity and thoroughly well thought out design of some of the recently installed traction plants in this country, such as say Bristol and Dublin, English plants compare more than favourably with any other similar plants in any part of the world. As regards line construction and design for poles and brackets, we are ahead of anyone else; and for old-fashioned towns with narrow and crooked streets the Dickinson or side trolley system, as first introduced by Mr. Alfred Dickinson in South Staffordshire, and improved upon at Bristol, is a great advance on anything which is to be found in America or on the Continent. But conditions in England and America differ vastly, and it is not necessary in the New American cities with perfectly straight streets to use the side trolley. American engineers, however, have not hesitated to thoroughly approve the side trolley, and they certainly would adopt it had they to meet the same conditions which are to be found in this country. As regards the improved artistic designs of poles, brackets and line construction, manufacturers, contractors, and tramway companies have not been slow in adopting the designs first got out for the roads in Bristol and Dublin and making them their own.

My endeavour has been to show that although it is undoubted that at the present moment we have to go to America if we want to secure a thoroughly workable electric traction plant, yet in years past it was this country which showed America the way.

But having considered the progress of electric traction in the last 25 years, a little speculation of the possibilities, or perhaps probabilities, may be indulged in. The capital invested in American street railways is about 280 millions sterling, or nearly a third of the total capital invested in English railways. This may give some idea of the importance to which this new and ever-growing industry has attained in so short a time. But it is not only to tramways that electric traction is applicable; it has a far wider and more important field, and it is more than probable—in fact nearly certain—that a quarter of a century hence, when we look back on the progress achieved, we shall have even more astonishing results to chronicle than those of the last 25 years. It is only a few years back that at the Institution of Civil Engineers, when the Liverpool Overhead Railway was discussed, several eminent engineers declared that it was impossible that electric traction could ever handle satisfactorily the enormous traffic of the Metropolitan and District Railway. What a change has taken place now, when the special committee appointed to investigate the ventilation question on these lines, declared after careful examination and due deliberation, that the only possible means of overcoming the smoke nuisance and securing proper ventilation was by the introduction of electric traction. Eminent engineers, such as Mr. Webb, of the London and North-Western Railway, have declared their belief in the future of electric traction. There is no need to invent any new system of high speed railways such as those proposed by Mr. Zipernowski, of Budapest, or by Mr. Behr, and to revolutionise the present road-bed, or track or cars. The only thing which will be necessary is a heavier road-bed and an improved system of signalling. What more easy where electricity is the motive power than to cut off automatically the current from the cars when the signal stands at danger, or to put on the brakes automatically? How much happier the life of the locomotive driver will be under these circumstances. There will be no more difficulty in starting heavy trains, and locomotives of practically any power can be constructed and yet kept within the proper size so as to go under existing bridges and through existing tunnels. As is well known at the present moment, the steam locomotive designer has practically reached the limit as far as power of engines is concerned. The adoption of electric locomotives will give him a new lease of life. As regards the transmission of any required power, the great drawback has so far been the enormous cost which would be entailed in the necessary feeders. This, however, is decreasing as the use of high voltages becomes more frequent. Naturally engineers hesitate to adopt these high tensions before such lines have been commercially constructed and have proved to be successful. This is now no longer the case, as at Los Angeles in California, 4,000 horse-power is being transmitted electrically by means of 3-phase currents a distance of 80 miles at a pressure of 33,000 volts. In the case of main line railways there is no objection to using 3-phase currents, and it is Mr. C. E. L. Brown's opinion that motors for railway work of any power can be constructed, and he is now occupied in building 3-phase motors which will be used on the Jungfrau railway. Such being the case, there will be no difficulty in running electric locomotives, hauling train or single motor cars say between London and Manchester, the power being supplied from one station in London and one in Manchester, transformers being placed at intervals along the line reducing the initial voltage of 33,000 volts down to say 500 or 600 volts.

It is, however, not necessary for the success of such a system to use 3-phase motors, and it would be quite possible and easy to use continuous current motors having rotary converters along the road which could easily be placed in the signalman's cabins and controlled by him. Rotary converters can practically be built any required size and with very high efficiency. In about a year from now such converters of a capacity of 800 kilowatts each will be running the Central London and transforming a high tension 3-phase current of 5,000 volts into a continuous current of from 500 to 600 volts. From the experience of the last few years, it seems certain that within the next few years all the suburban and metropolitan lines will be run by electricity, and there is not much reasonable doubt that within a comparatively short time, main line railways having a heavy passenger traffic will also be run by electricity.

This would not mean the total abolition of the steam locomotive, as in all probability this would be still used for freight trains and for lines having but a small amount of traffic. In countries where water-power is available and can be utilised without heavy initial expenditure, even on these last mentioned lines electric traction would reign supreme.

In considering the history of electric traction as far as England is concerned, there obtains a peculiar

condition which is rarely to be found outside this country. Municipalities have made up their minds that it is the proper thing that they should own everything which runs through their streets, such as water, gas, electric light, and tramways, and there is no reason why, if properly handled, they should not be as successful in the hands of an able corporation as in that of a company. There is, however, one great danger which is to be feared, much more in cases where corporations own and equip their tramways than in those where private companies do so. Corporations are composed of individuals who are elected for comparatively short periods of time, and who, therefore, as long as they temporarily please their electors may often be entirely indifferent as to the future and final success of the electric tramways which they may be engaged in equipping. There is much danger in this case of the lowest tender rule reigning supreme. This is most fatal in the case of an electric tramway, where for the success of the whole undertaking, each portion of it must be designed, built and put in by somebody who is anxious for the success of the whole system, and who has not put in a bid simply to get the contract at any price and then to try and get out of it without loss by cheap materials, cheap labour, and that bugbear of extras. At present there are comparatively speaking very few who know all the intricacies entering into an electric traction scheme, or who are capable of intelligently watching the contractors and seeing that only the best materials and best work are put in. It is the great danger of the municipal ownership of electric tramways that when these are about to be equipped numberless tenders come in from new and inexperienced firms who have never done similar work, who tender at ridiculously low figures, and who, when they get the job, gain their experience at the expense of the tramway. It is quite natural that municipal committees should try to save as much of the rate-payer's money as they can, but it should never be lost sight of that a slightly increased initial expense may mean perfect success, whereas a small saving in the primary equipment may mean total failure and a continuous drain on the rates.

The combination of the lighting and traction interests of a corporation may, in many instances, be an exceedingly good thing, but care should be taken not to burden the tramway for the benefit of the lighting, by charging exorbitant rates for the supply of current. In no case, at any rate where a fair amount of current is required, should much over a penny per Board of Trade unit be charged.

Municipal ownership promises much, but in the case where strong tramway companies are in the field, it may often be very much wiser to come to an arrangement with them instead of fighting them.

It has been attempted to briefly summarise the history of the past 25 years of electric traction, to show that the English inventor, engineer, and manufacturer, were the first to appreciate the advantage of this method of propulsion and to adopt it. Unfortunately they did not profit by the lead they had obtained, and the Americans have so much improved their various methods since, that at the present moment the only chance for English manufacturers would seem to be to try and master all the improvements of our American cousins, and to improve upon these again, otherwise there is great danger of their being left in the lurch.

An attempt has also been made to show the enormous possibilities of electric traction not only on tramways, but on main line railways, and to bring home a fact which ought to be more widely known than it is, that in the near future the electric transmission of power for traction and generally for motive work will far surpass anything that has or that could be done in lighting. It is not at all impossible that in the near future factories will no longer have chimneys, and railways will no longer have smoky locomotives, but instead large power stations will be dotted all over the kingdom, generating vast power at the most economical rate and supplying it to every consumer and for every purpose.

TWENTY-FIVE YEARS OF TELEGRAPHIC PROGRESS.

By W. H. PREECE, C.B., F.R.S.

There are doubtless many who would argue that had not the telegraph system of this country been shackled by its connection with the State, the actual progress which would have been made since the transfer (in 1870) would have been far greater than it actually has been. Whether the argument is a correct one or not matters little, but that a very substantial progress indeed has been made since 1872, the date from which our record is to commence, admits of no doubt whatever. Statistics confirm it most amply. No better commencement can be made than to state the number of telegrams which are recorded as having passed over the Postal Telegraph wires in 1871–2 and in 1896–97. In the former statistical year the total amounted to 10,207,362, whilst in 1896–97 this total had grown to the large figure of 79,423,556, or nearly an eightfold increase. In 1871-72, the number of offices open was about 3,500, and in 1896-97 this had increased to 8,282. Again, let us compare the line and wire mileages; these in 1871–72 amounted to 21,843 and 94,991 respectively; they now (1896–97) total 41,393 and 279,935.

In 1871-72 the total number of instruments in use was 8,945; in 1896-7 the total number had increased up to 30,132, made up as follows:—Automatic, 436; Quadruplex, 137; Multiplex, 31; Repeaters, 131; Sounders, 4,735; Morse Printers, 739; Hughes, 77; Bright's Bell, 952; Single Needle, 4,714; A.B.C., 5,018; Telephones, 8,843; Miscellaneous, 4,319.

We see not only a very large increase in the total of apparatus, but we have the introduction of the quadruplex and multiplex, systems which, originated by American ingenuity, have, more especially in the case of the multiplex, been very materially modified in important points of detail, without which their efficiency would have been appreciably less than at present.

Turning now to what is unmistakably an English form of apparatus, viz., the "Wheatstone Automatic," in 1872 a speed of 100 words a minute was considered a very respectable achievement; now, 600 words has been practically obtained, although for commercial, and not for electrical or mechanical, reasons, 400 words is the practical limit at which working is carried on. A comparison of the mechanism of the apparatus as it at present exists, with the older form, is an instructive study. The present high speed, it may be stated, has been largely due to the inclusion of a "shunted condenser" in the receiving circuit, an arrangement first applied in 1882. As regards the value of the Wheatstone, without its use the enormous amount of press traffic passing over the wires could not possibly be handled.

If we may take elaboration as an example of progress, we have it in the form of the "fast-speed repeaters" used in connection with the Wheatstone apparatus when the latter have to be worked over exceptionally long circuits. The present form of this apparatus, for use on cable circuits, comprises 41 instruments of 26 different forms; it is arranged to work "Bridge" Duplex on the cable side, and "Differential" on the land section of the circuit. The value of Repeaters for speed purposes may be illustrated by the fact that *direct* working between London and Aberdeen (560 miles) would not be possible at a higher speed than 40 words per minute, whereas with Repeaters at Leeds and Edinburgh the working speed is fixed at 350 words. These Repeaters in their present efficient form are an introduction within the last 25 years and are marvellous examples of ingenuity.

The past period of 25 years has witnessed the introduction of the "Sounder" into the Postal Telegraph system to the partial disuse of the Morse Inker, although the latter cannot yet be said to have become an obsolete piece of apparatus. In the use of the two forms of instrument, the Sounder and the Inker, this country

stands intermediate between America and the Continent. America uses the Sounder exclusively, whilst on the Continent the Inker is practically the standard form of instrument. A small but important addition to all local apparatus, *i.e.*, apparatus worked by relays, has been the general introduction of a double wound "spark coil," or shunt of high resistance, across the terminals of the same; this has resulted in the suppression of the spark at the relay contacts and a consequent greater certainty of action. The improvements in point of detail, which are really of far greater importance than might at first sight be imagined, are practically legion, and can only be appreciated by those who for a long period of time have had the handling of apparatus.

The last 25 years has witnessed the introduction of the Fuller bichromate battery, a type which has done most excellent work; the several types of Daniell cell, which have been used, have, as a result of the "survival of the fittest" law, been reduced to one standard pattern.

The use of currents produced by dynamos has not received acceptance for telegraphic purposes in this country, the actual conditions required for working the circuits practically not admitting of their employment, but a great revolution has come about in the adoption of "accumulators" in all large offices; the result being a great improvement in working and a saving in maintenance and in space. The use of accumulators has required many matters of detail to ensure safety and reliability of working to be worked out; these, however, have been most carefully and skilfully dealt with by the engineering staff, with most excellent results.

"Line construction" has made vast strides within the period under review, the old larch pole of irregular section and not over-regular run has given way to the present fine looking fir timber of symmetrical form. Preservation by "Burnettising," "Kyanising," and "Boucherising," is a thing of the past, and now "Creosoting" is universal. A line of less than a dozen wires which at the beginning of the 25 years' period would be thought a heavy one is looked on as insignificant now, and several of these lines which at the time they were constructed were thought to afford an ample margin for future wants have had to be entirely rebuilt with stouter timber, in order to afford efficient strength for the greatly increased number of wires that the increase of message traffic, and especially the introduction of the telephone, has necessitated. The use of "H" poles strongly and rigidly bound together with iron stays has become very general.

A new departure in the shape of iron arms, introduced by Mr. Langdon of the Midland Railway, in the place of those of oak, has been recently made, and an important line on the Midland Railway has been constructed in this manner; the arms being of tubular section are very strong, and at the same time are light.

A marked improvement in "Insulators" was the introduction of the "screw" pattern in 1877, a form which enabled the cleaning of the porcelain to be greatly facilitated, as the cups instead of being cemented were only screwed on to the bolts.

In connection with aerial lines the change which has come about in the description of wire used is striking. In the very early days of telegraphy copper wire was employed, but was very soon abandoned in consequence of its lack of strength, and also, it has been stated, in consequence of its liability to be stolen, though there is no evidence to prove that the last statement ever had any foundation in fact. The employment of galvanised iron became practically universal, and in spite of its inferior conducting power has done excellent service. The continued demand for this iron telegraph wire has resulted in a very great improvement in its manufacture, not only as regards its strength, but notably in its specific conductivity, which has probably been increased more than 50 per cent. within the last 25 years. A bold and costly experiment of erecting a copper wire from London to Newcastle, in 1887, has revolutionised the hitherto universal practice of employing iron wire, and the discovery that for long lines the employment of copper, on account of its low electro-magnetic inertia, was vitally necessary, has led to a great extension in its use, not only for telegraphic purposes but also almost universally for telephonic use. The improvement which has resulted in the manufacture of the copper has resulted in the "hard-drawn" quality now so well known, which has a conductivity exceeding 100 per cent. of the Matthiessen standard. Doubtless the extended use of the metal for telegraph lines has largely been the result of the low price which has so long reigned, a price which, from a telegraphic point of view, it is to be hoped will be maintained. The advantage which copper possesses over galvanised iron (irrespective of the absence of electro-magnetic inertia) is instanced by the fact that an 800 lbs. iron wire, the largest size which can practically be employed, has a resistance of 6·66 standard ohms per mile, whilst an 800-lbs. copper wire has a resistance of but 1·098, the minimum breaking strain of the two being very nearly alike, viz., 2,480 in the case of the iron and 2,400 for copper; moreover the durability of copper is far greater than that of iron.

With reference to the great increase in wires necessitated by increased traffic, it may be mentioned that nearly all the main roads available for the purpose have now been taken up on both sides with lines of telegraph poles, and in view of the still increasing requirements, the problem of a satisfactory system of underground wires has had to be tackled. The actual amount of underground work at present in existence amounts to no less than 942 miles of pipes, and 30,058 miles of wire, of which 17,000 miles of wire are within the Metropolitan area alone. None of this wire, however, with the exception of a section between Manchester and Liverpool, comes under the category of main line systems; the wire is actually only used for the purpose of avoiding the employment of aerial wires within the limits of a town where the use of poles is impracticable, or rather is forbidden by the local authorities. The introduction of "paper cables" seems likely to materially help towards solving the problem of underground communication, as the electrostatic capacity of these cables reaches a low point hitherto unattainable, and moreover, the item of expense, which has hitherto been a great barrier, is in the case of paper insulation reduced to a minimum. At the present time a paper cable of 76 wires is in progress of being laid between London and Birmingham, and although this cannot be looked upon in the light of an experiment only, still the experience which will be gained will doubtless have a material effect in showing to what extent long lengths of underground work will be advisable in the future.

Turning now to the question of progress as indicated by the extent of plant, workshops, &c., which used to be sufficient for the needs of the postal telegraph service and what is necessary now, it may be pointed out that a small establishment (originally the property of the Electrical International Telegraph Company) at Gloucester Road, Chalk Farm, and covering about one acre of ground, was sufficient in 1872 to contain the workshops and stores of the department. Now, the major portion of the land occupied by the old Clerkenwell prison, 10 acres, and a fine factory employing 200 men at Holloway, is taxed to the utmost to keep pace with the requirements of the service. More than 50,000 pieces of apparatus are passed through the mechanics' workshops each year, and this number tends to augment year by year.

It is, perhaps, somewhat invidious to make comparisons, but it is none the less a fact that though we in England have been rapidly advancing in telegraph matters, not only in regard to improvements devised by our own engineering staff (which improvements, though unknown to the public from the simple fact that they are not patented at home nor published abroad, are nevertheless very real indeed) but also in regard to our readily taking up and improving such inventions as have here and there been devised by other countries, yet other nationalities, even the United States of America, have almost stood still, except from the point of view of increase of mileage of wire and of the number of offices opened.

The introduction of the 6d. tariff in 1890 has had, of

course, much to do with the increase of volume in telegraphic business, but the able character of the whole engineering staff has enabled this increase to be properly handled, to the general satisfaction of the exacting public, who as a rule are not given to praising what is done well by their own servants, and who seldom fail to find fault on the slightest provocation.

TWENTY-FIVE YEARS' DEVELOPMENTS IN MAGNETISM.

By PROF. ANDREW JAMIESON, M.Inst.C.E., F.R.S.E., &c.
Of the Glasgow and West of Scotland Technical College.

THE year 1873 may be considered a memorable one in the history of magnetism and electricity, for Gramme had just introduced his dynamo into this country, Siemens Brothers had just patented their drum armature and self-exciting series wound dynamo, "The Society of Telegraph Engineers" * had just issued the first volume of their Proceedings, the "Reports of the Committee on Electrical Standards," appointed by the British Association for the Advancement of Science, were revised and reprinted for public use, together with a report to "The Royal Society on 'Units of Electrical Resistance,'" and Professor Fleming Jenkin's Cantor Lectures on "Submarine Telegraphy." *The Telegraphic Journal and Electrical Review* was launched (two months previously), and Professor Jenkin issued his novel and up-to-date text book on "Electricity and Magnetism." In the preface to the latter book there appears the following interesting statement, which accurately describes the disjointed and backward condition of the general knowledge on this subject:—"It is also not a little curious that the science known to the practical men was, so to speak, far more scientific than the science of the text books. These latter contain an apparently incoherent series of facts, and it is only by considerable mental labour, that after reading the long roll of disjointed experiments the student can even approximately understand any one experiment in its entirety."

The early history and the discovery of magnetism is lost in obscurity; for all we know is, that the name magnet (*magnes lapis*) was assigned by the ancients to certain brown coloured stones (found in Magnesia, Asia Minor), which possessed the property of attracting small pieces of iron. The Chinese are, however, credited with having first applied these natural magnets, about A.D. 1100, to the purposes of navigation. This was all, or nearly all, that was known of the magnet and its properties until Dr. Gilbert, the physician to Queen Elizabeth, published his discoveries in his famous work, "De Magnete." From that date until 1820 very little information, indeed, was added to what Dr. Gilbert had announced. On July 21st of that year, Œrsted, the Professor of Physics in Copenhagen University, published his famous letter, "Experiments on the Effect of Electric Action on the Magnetic Needle."† In 1831, Faraday announced his discovery that the electro-motive force set up in a conducting circuit placed in a magnetic field is proportional to the rate at which the number of included lines of force is varying. This discovery was followed in 1834 by that of Lenz law, which states that in all cases of electro-magnetic induction, the induced currents have such a direction that their reaction tends to stop the motion which produces them. Faraday's numerous experimental researches in electricity and magnetism, as reprinted, in three volumes from the *Philosophical Transactions* of 1831 to 1852, were undoubtedly considered as the catechism of the practical electrician. They had, however, run out of print by 1873, and were only to be found in the private and public libraries; * so that many young electricians of that date had never seen them. It is therefore doubtful if they had a definite conception of lines of force of the magnetic circuit, of the action and reaction between a magnet's field, and the magnetic field due to an electric current, as well as how to measure the strength of a field in magnetic units. These researches, however, must undoubtedly have stimulated and enabled such men as Pixii (of Paris in 1832), and Saxton (in 1833) to devise magneto-electric machines, whereby brilliant sparks, shocks, heat and chemical decomposition were produced. They no doubt also paved the way for Cooke and Wheatstone's (1837 and following) telegraph instruments, Bain's (1841 and others) electric clocks, Ruhmkorff's induction coil (1851), as well as a whole host of miscellaneous practical applications of electricity and magnetism.† The laying of the 1857 Atlantic cable, and the difficulty of receiving signals therefrom owing to the want of sensitiveness in the electro-magnetic apparatus which was then at the disposal of electricians, induced Sir William Thomson to devise and perfect his mirror galvanometer before the laying of the 1865-66 cable. From that date until 1873 he had invented, improved, and put into working order many of his beautiful siphon recorders, which to this day are doing good work at many of our submarine cable stations. These instruments depend largely for their electro-magnetic action on the principles laid down by Œrsted, Ampere and Faraday, and are beautiful examples of the practical applications of theory to practice.

If we inspect the several volumes of the *Electrical Review* for the past 25 years, we find contained therein a very complete account of the developments in magnetism during that time as well as references to the earlier experimenters who have already been mentioned, and to the work of such other notable scientists as Coulomb, Gauss, Weber, &c. It is, however, not only curious but interesting to note that until about 1880, when the self-exciting dynamo had been fairly introduced into this country, that the term dynamo very seldom occurs in its pages, and, further, that the chief experimenters on magnetism, &c., referred to in the *Electrical Review*, were for the most part foreigners, and of these, Frenchmen are by far the most numerous. For example, we frequently come across the names of Jamin, Gaugain, Riecke, Tréves, Treve, Bouty, Risch, Gramme, Becquerel, Cazin, Auerbech, Challis, Count du Moncel, Reiss, Hefner-Alteneck, Obach, Jablochkoff, &c., then the Americans, Rowland, E. Gray, Bell, Edison, &c. The British names that appear in the Journal and in the Proceedings of the Society of Telegraph Engineers are Sir William Thomson, Jenkin, Culley, Sabine, W. H. Preece, the Brothers Varley, Ayrton, Hughes, C. W. Siemens, Winter, Ewing, &c.

One of the best examples of the skilful use of a good knowledge of the properties of magnets was displayed by Sir Wm. Thomson when he introduced his mariners' compass in 1876. It was a great advance upon any previous compass, and put into the hands of the navigator a really reliable instrument. He minimised the frictional inertia, semi-circular, quadrantal, and heeling, errors, and supplied the means of quickly ascertaining if any compass error had crept in—due to a change in the ship's magnetism or due to a change in the quantity, quality, or position of the cargo—without having recourse to observations of the heavenly bodies or of fixed points on shore. So much has this

* The name of this society was changed to that of "The Society of Telegraph Engineers and Electricians" in December, 1880, and again changed to that of "The Institution of Electrical Engineers" in November, 1888.

† A verbatim copy of Prof. Œrsted's original Latin letter, together with an English translation and a *facsimile* of his signature, will be found in Volume V., page 469, of the 1876 Proceedings of the "Society of Telegraph Engineers."

* A *facsimile* reprint of Professor Michael Faraday's *Experimental Researches* was, however, fortunately issued by Bernard Quaritch, of 15, Piccadilly, London, soon after 1873, under the supervision of Mr. (now Sir) James Sivewright, one of the first editors of the *Electrical Review*.

† For dates and descriptions of early magneto machines, such as Werner Siemens, 1857; Holmes, 1862; Wilde, 1866; Ladd & Tisley, 1867; Gramme, 1872; C. W. Siemens' 1873 dynamo, as well as many early miscellaneous applications of magnetism, such as Sir William Thomson's mirror galvanometers, electrometers, recorders, &c., see "Text book on Electricity," by Henry M. Noad, F.R.S., revised by W. H. Preece: Crosby, Lockwood & Co., 1879; also Col. Bolton's "Historical Notes on the Electric Light, &c.," Volumes V., XI. and XV. of "The Proceedings of the Institution of Electrical Engineers."

invention been appreciated by seamen, that scarcely a British man-of-war or a mercantile steamer of any great importance leaves our shores, without having one or more of his compasses on board.

In 1877, Mr. W. H. Preece read a paper on "The Telephone" before the British Association at its Plymouth meeting, which was printed in the Journal of the Society of Telegraph Engineers, and reported in this periodical. The extraordinary sensitiveness of the Bell Telephone, its very small changes of magnetism due to the minute currents generated in its electro-magnet, greatly interested and astonished British electricians. No one could have foretold at that date what an extraordinary development would arise in the application of that instrument and in the many electro-magnetic devices that have been invented and applied in connection with its introduction to almost every city, town, village, and district throughout the civilised world.

It was not until February, 1880, that a paper appeared before the Society of Telegraph Engineers dealing with the magnetism, &c., involved in the action of a dynamo. In that paper Mr. Alexander Siemens related "Some Recent Improvements in Electric Light Apparatus" and produced characteristic curves of a series and a shunt wound dynamo. These and other curves had been suggested in the previous year by Dr. John Hopkinson, in a paper read before the Institution of Mechanical Engineers.

From 1880 to the present year, there has been one unbroken series of investigations by Physicists, Electricians and Electrical Engineers into the properties of Magnetism and their practical applications. Any really useful development which has taken place during that time is almost certain to be found in the pages of the *Electrical Review*, and since very full reports of the proceedings of the Institution of Electrical Engineers, as well as notices of other society's work, appears as soon as possible after a paper has been read, subscribers to this journal are kept very fully abreast of the times. It is impossible in this short article to do more than notice a few of the more important papers read at the Institution, but we take this opportunity of stating that the society should endeavour to bring up to date Col. Bolton's excellent synopsis of patents relating to electric light electrical apparatus, for the last or third article appeared in Volume XV., 1886, and they should also bring up to date the index of their journal, since it has not been carried further than Volume XX., 1891. Of the more important communications relating more or less to magnetism, one classical paper which has been admired and its contents cherished by electrical engineers was that read by Professor D. E. Hughes in May, 1883 (Volume XII., Inst. E.E.), on "The Cause of Evident Magnetism in Iron, Steel and other Magnetic Bodies." It opened the eyes of the ordinary practical electrician and engineer to the simplicity and beauty of the molecular theory of magnetism. In the same year and volume we have a paper by Professors Ayrton and Perry on "Electromotors and their Government," which brought before us the principle and action of, and inter-action of compound wound dynamos and motors. In 1886, Mr. Gisbert Kapp (Volume XV., Inst. E.E., 1886) read a most suggestive paper on "The Predetermination of Characteristic Curves of Dynamos," wherein he points out the simple equation for the magnetic circuit, and how it is of similar form to that of Ohm's law. This paper led up to a good discussion, and impressed on dynamo makers the necessity of ascertaining the permeability of the iron or steel which they used. Then we come to Dr. J. Hopkinson's most instructive and suggestive presidential address on "Magnetism" to the Institution of Electrical Engineers in 1890 (Volume XIX.) From these, together with the several papers by Messrs. Stock, Mordey, Forbes, Swinburne, Esson, Fleming, Sayers, &c., as well as Professors Ayrton and Perry, and Lord Kelvin's on "Measuring Instruments," all of which have received due prominence in the *Electrical Review*, we see how busy our electricians and electrical engineers have been during the last decade. To Professor Ewing and Dr. John Hopkinson are due our best thanks for their communications to the Royal Society, &c., on "Magnetism, its Permeability and Hysteresis, &c.," and to the latter, as well as to Professor Silvanus P. Thompson, and to Professor Andrew Gray, for having put into book form the latest experimental and mathematical evidence of the laws and actions of magnets and electro-magnetism.* Not only have our British workers in this field been very busy, but German, French, Italian, and American electricians, engineers, and physicists have been keeping step with us, and in some notable instances forging ahead of our theories, experiments and practice, and their doings have been duly noted in this journal.

At the 1893 meeting of "The International Congress of Electricians," which was held in Chicago, the committee on Notation recommended the use of the names, Gauss, Weber, Gilbert, and Œrsted, to represent certain magnetic quantities.† Their recommendations in this respect have not found much favour with British electrical engineers.

One of the last and most striking experiments on magnetism is described in Volume XLI. of the *Electrical Review* of October 22nd, 1897. These consist of the investigations by Dr. David K. Morris on "The Effect of Temperature on the Magnetic Qualities of Iron." Dr. Morris has succeeded in obtaining simultaneous measurements of the electrical resistance and magnetic permeability of iron throughout cycles, from ordinary temperatures up to a white heat under various conditions of annealing. These interesting and instructive experiments should be performed in every college electrical laboratory. Finally, the writer of this article has much pleasure in announcing that he has just received a small quantity of *magnetic sand* from Lima, South America, through his old student, Mr. Alexander Davidson, Electrician of the West Coast of South American Company's submarine cables. This magnetic sand is much more easily attracted by a magnet than iron filings, and is reported to exist in a quarry of some extent. Truly almost every day brings forth new ideas or applications of this mysterious force—magnetism, and may we live to see the day when someone will discover what it is and why it is confined to certain substances.

SOME NOTES ON VOL. I. OF THE "TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW," 1872–1873.

By W. M. MORDEY.

After a hurried glance at some of the work before 1872, it is interesting to look through the early volumes of the *Telegraphic Journal and Electrical Review*. An examination of the contents of Volume I. (November 15th, 1872, to November 15th, 1873) sometimes gives rise to surprise at the greatness of the changes that have occurred since then—sometimes at their smallness.

For instance, on page 4 of the very first number there is described and illustrated a machine that we should now call an inductor alternator; true, it is a very little one, and was only put forward by its inventor, Sir Charles Wheatstone, as a means of ringing an electric bell, or working a counting gear—they were much given to variations on the electric bell theme in those days—without the "troublesome chemical operations" involved in the use of batteries. This admirable alternate current device was put into the Bank of England about the same time (if the writer's memory is not at fault), and is probably still in use there.

* See Professor Ewing's book on "Magnetic Induction in Iron and other Metals":—The Electrical Publishing Company, London; and "The Theory and Practice of Absolute Measurements in Electricity and Magnetism," by Professor Andrew Gray:—Macmillan & Co., London. Two vols. Professor S. P. Thompson's Text Books on Dynamo Machinery, and Electricity, and Magnetism.

† See Munro and Jamieson's Pocket book of "Electrical Rules and Tables," 12th or 13th edition, p. XVIII., for a complete copy of the Committee's recommendations.

Then, on page 9 of the same number we have the first appearance of the Clark cell. A long abstract of Mr. Latimer Clark's original Royal Society paper sets forth the difficulties and importance of providing "a material standard of electro-motive force," refers to the recommendations of the British Association Committees that a C. G. S. system of electro-magnetic units be adopted, describes the cell, explains how to use it, and gives results of tests. Let us congratulate Mr. Latimer Clark on the 25 years of useful work done by his cell, and on the literal carrying out of the useful programme sketched in the last paragraph of his paper: "The use "of such a standard, combined with an auxiliary battery "in the manner above described, admits of a variety of "applications which it is believed will be found of "great value in electrical research."

The second number of the paper (December 15th, 1872) contains an account of the Planté secondary battery, with a figure showing a cell being charged by two Bunsen elements. The three columns of description show how slight must have been the hold obtained by mechanical generators at the time. The description refers repeatedly to charging by Bunsen cells, but never mentions charging by a machine; although one of the figures shows an arc light being supplied, showing that some considerable power was used. The power of the battery is stated, in the language of the times, as sufficient "to heat to redness a platinum wire of two metres in "length, and 0·5 mm. in diameter." This was a recognised practical standard in those days, and for long afterwards, in spite of British Association Committees and Mr. Latimer Clark. Even in the early eighties this kind of standard persisted. On one occasion at that time, the writer was rather impatiently told by the late Mr. Ladd that he did not want to know anything about its volts or amperes, but how many yards of No. 16 copper wire a certain dynamo would heat.

But measurement was in the air. In the same second number of the journal appears an excellent table of copper wires — diameters, lengths, resistances—by Mr. Walter Hall, in which "the unit of resistance used is the *ohmad* adopted by the British Association." And, turning over the pages, we find in the President's address at the British Association meeting, evidence of the obligations of science and practice to each other — "the great practical importance of telegraphy having caused the methods of electrical measurement to be rapidly perfected" (p. 287).

In this same second number is a description of the Hughes' type-printing telegraph, which we may mention, if only as giving an opportunity for expressing the pleasure given by the announcement, a few days ago, of the decoration of Professor Hughes by the Belgian Government*—making the ninth high class decoration conferred on him by European Governments. In this country we seem to go on the principle that those who are unadorned are adorned the most.

The Society of Telegraph Engineers had just come into existence, and its proceedings are duly reported. Thus, in the third number (January 15th, 1873) we find the retiring President, Dr. (afterwards Sir) William Siemens, addressing the Society on its history during its short existence of nine months. We must not stay to refer to the reports of the society's meetings, where "Sir William Thomson," Preece, Webber, Ayrton, and others were giving their first contributions to the "Proceedings."

The fourth number (February 15th, 1873) contains an account of the principle of "the constant current magneto-electric apparatus of M. Gramme," with some results of tests made by Mr. Sabine, showing that the electro-motive force (expressed in *Daniells*) was approximately proportional to the number of "turns of the handle per minute." This is the first reference to the dynamo in the *Electrical Review*, and it is satisfactory to find it so practical, and to the point.

The first issue of Fleeming Jenkin's "Electricity and Magnetism" is reviewed on page 175. The publication of this book marked a radical change in the text-book treatment of the subject. Previous writers had dealt in what Professor Jenkin rather slightingly terms, "the electricity of the schools." One exception occurs to the present writer. In the old text-book of Ferguson there is a very good and clear explanation of the meaning of the new C. G. S. electrical units. Professor Fleeming Jenkin's preface is rather severe. If "Science is measurement," his preface shows that the really scientific people were the practical telegraph engineers. He says: "The difference between the electricity of the schools and of the testing office has been mainly brought about by the absolute necessity in practice for definite measurement." The *Electrical Review* reviewer well said: "To have recognised this difference is a great step in advance upon former electrical teaching."

That the *Telegraphic Journal* was at once successful is evident from the fact that after the issue of the seventh number, on May 15th, 1873, it became a fortnightly instead of a monthly journal.

The number of the journal for July 1st, 1873, contains an important paper by Wilde on "Improvements in Electro-Magnetic Induction Machines." This is one of the classical papers which must always be of great interest. Wilde was evidently a strong believer in the heating-of-wire mode of measurement. He describes (page 183) how one machine will melt 8 feet of No. 16 iron wire; and, at a higher speed, 12 feet of No. 15 iron wire (he might have kept the same diameter, at least). He proceeds:—"As soon as the heating or "fusing of an iron wire of a given length and section "comes to be an acknowledged measure of powerful "electric currents, as well as a method of comparison "between the power of electromotors of different kinds, "as it must ultimately be, the significance of this result "will be fully realised." Note here the word "electromotor" means generator.

Further on he refers to his previous paper on "Rendering Synchronous the Rotation of the Armatures on a number of Electro-Magnetic Induction Machines" (a paper, that is, on parallel working), and gives an illustration, an explanation of which might profitably be set as an examination question now. "I "stated that this (synchronous) property would be "available when the machines were used for the electro-"deposition of metals from their solutions. It has, "however, been found that the small resistance, presented "by depositing solutions to the passage of the currents, "prevents this property from manifesting itself (in "accordance with what I stated in my paper respecting "the effect of joining the poles by a good conductor). "It is only when the machines are employed for the "production of electric light or other purposes, where the "external resistance is considerable, that this electro-"mechanical function of the current comes into useful "operation."

The man who grappled with problems of this sort with a few feet of melting No. 16 iron wire for ammeter and voltmeter, and with the text-books of "the electricity of the schools" as works of reference, has our respectful admiration and sympathy.

The work of the early telegraph engineers was approaching completion. The telegraphs of the country were being combined into one uniform system by the State. As marking the change from the old to the new we find recorded in Vol. I. (August 15th, 1873), the death of one of the English telegraph pioneers, Sir Francis Ronalds, who in 1823 had published an account of a telegraph line tried by him. The line was laid in a covered ditch in his garden, the wire being placed in glass tubes surrounded by wooden troughs lined with pitch. He also used eight miles of wire suspended by silk cords hung on frames. He was knighted in 1870 in recognition of this work. In Ronalds' house, till recently, there lived a pioneer of a different art, or of many arts, William Morris, and strange to say, that house now shelters a young and cheery electrical Jack-the-giant-killer, who won his spurs and our thanks by ending a task well begun and continued by the *Electrical Review*, for he un-Harnessed electricity. This same slayer of giants assures the writer that remains of Ronalds' first under-

* *Electrical Review*, page 582, *ante*.

ground telegraph line are sometimes turned up in his garden. It may not be out of place to suggest that the proper resting place for any such Ronalds' relics is the library bequeathed by Ronalds to the Institution of Electrical Engineers.

In the issue of September 1st, 1873, appears an account of trials at St. Petersburg of an electric light, the invention of Mr. A. Lodyguine, produced by heating a piece of charcoal or other bad conductor enclosed in a glass tube, hermetically sealed, after the air had been exhausted and replaced by a gas which would not combine with the charcoal. "Taking into consideration," says this hopeful report from *Golos*, "that one machine "worked by a small three horse-power engine, is capable "of lighting many hundreds of lanterns. . . . we "can state that, by calculations made, this electric light "can be produced at a fifth of the cost of coal-gas."

We know that Werner Siemens in 1867 introduced the name *dynamo-electric machine* when he first described the self-exciting machine—the name appears in this first volume, but only in connection with a description of a mine-exploder by Siemens. Except Wilde's, there is no mechanical generator of engineering importance described in this first volume. The machines shown are little hand-driven things—not much more than toys.

There are very many other things in Volume I. that are interesting as showing the state of the art of the electrical engineer when the *Telegraphic Journal and Electrical Review* was started. With means very ill-adapted to the work, the pioneers were clearing the ground. But almost 10 years had to pass before the work began to develop rapidly and on sound lines. It then attracted the attention of commercial men, money was provided, and progress became possible.

The explanation of the subsequent progress is given in one word—"measurement." The electricians who have been engaged during the last 20 years in this work have had the enormous advantage of the possession of easy and simple methods of measurement, resulting from the practical needs of the telegraph men, and based on the scientific work of Clark Maxwell, Kelvin, and many others, worked into systematic shape by the British Association Committees, taught to electric light men, and pressed into their understanding by precept, by example, and often by means of instruments devised to meet their requirements—by Ayrton, Perry, Siemens, Silvanus Thompson, and many more. Instead of having to wait for months or years, as in many other branches of engineering, recent workers have been able to keep a constant check on their work by quantitative measurements, simply and quickly obtained; and so by ascertaining as they went on the results of the work, and the effects even of small changes and modifications in machines and system and apparatus, they have been able to advance with unexampled rapidity.

It may be thought as the progress of the last few years has been so remarkable that the next few years may be expected to show similar progress. This, to the writer, seems unlikely. It appears probable that the *Electrical Review* will have mainly to record commercial and industrial progress rather than startling scientific or technical advances. The establishment all over the world of substantial electricity works, with all their distribution systems, must be taken as a proof that electrical engineers and commercial men are convinced that the principles now being followed are, broadly, of a sound and permanent character.

TWENTY-FIVE YEARS' DEVELOPMENTS IN CENTRAL STATIONS.

By ROBERT HAMMOND, M.I.E.E.

My title is of the editor's invention, not mine, and I cannot at the outset refrain from making a tilt at it. "Central Station" has always appeared to me to be an ugly and inappropriate term for electricity supply works. In practice it gets abbreviated to "Station," and, in provincial towns, one never knows whether the railway station or the electricity works is being referred to. It is true that electricity supply works is rather too stately for ordinary use, but why not *Electricity Works*, like *Gas Works?* It apparently did not strike the pioneers of the gas industry to designate their generating works as central stations. I almost wish they had been struck with the idea, it would have prevented electrical engineers adopting the term.

To turn to my subject, "Twenty-five Years' Developments in Central Stations," I limit my review to works in the United Kingdom. Five-and-twenty years ago there were no central stations in the United Kingdom, nor had they been dreamed of. Defining a central station as a place at which electrical energy is "generated" for distribution in an area outside the premises in which the generating plant is fixed, it may be claimed that the first central station in the United Kingdom was laid down in the year 1878. This station was situated on the Thames Embankment and was established by the Metropolitan Board of Works for the purpose of lighting the Embankment on the Jablochkoff system. At about the same time the Commissioners of Sewers carried out an experiment on similar lines in the City of London, Holborn Viaduct being electrically lighted. The works were controlled by the Societé Générale de l'Electricité, and after running for a period —I think about six months and 18 months respectively— were closed by the determination of the contracts with the Metropolitan Board of Works and the Commissioners of Sewers.

These experiments, crude and very hastily arranged, as all pioneer work must be, were made prior to the perfection of the incandescent lamp by Mr. Swan in 1880, and only the Jablochkoff arc lamps, or candles, as they were termed, were used, but they completely demonstrated the superiority of electricity over gas for public street lighting.

Three years later, in 1881, three "central stations" of a more ambitious character were laid down respectively by Siemens Brothers, The Anglo-American Brush Company, and the Electric Lighting and Power Generation Company, for the lighting of the streets of the City of London. The lighting was inaugurated in March of 1881, and the contracts were divided between the three concerns in the following proportions:—

Siemens Brothers.—The lighting of London Bridge, Cheapside, and King William Street for 12 months at a cost of £3,720.

The Anglo-American Brush Company.—The lighting of Blackfriars Bridge, Bridge Street, Ludgate Hill, and St. Paul's Churchyard, at a cost of £1,410.

The Electric Lighting Company.—The lighting of Southwark Bridge, Queen Victoria Street, and Queen Street for 12 months at a cost of £2,930.

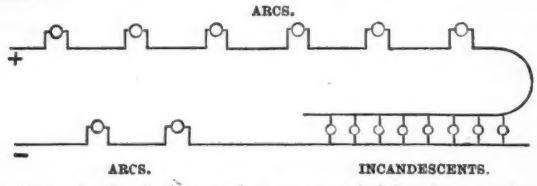
Messrs. Siemens were the only contractors who buried their conductors wholly under ground, and these conductors, I believe, remain under ground to this day. The other contractors adopted the overhead system. These central stations, if they may be so called, disappeared in their turn when the contracts expired.

Going back to these pioneer days, I cannot suppress a few personal reminiscences. My first essay in electric lighting was in 1880 when I carried out for Messrs. Bernhard Samuelson & Company, of Middlesborough, the lighting by arc lamps of the gantry behind their blast furnaces, where, through bad lighting, they had lost a few lives.

This led to my undertaking in 1881 to light the Steel Works of Bolckow, Vaughan, where, previous to the introduction of the electric light, all the processes were continuous except the rail straightening, and this could be carried on only during the day. So sceptical was Mr. Winsor Richards of the straightening of steel rails by artificial light that he only consented to the experiment provided that his firm was not put to a penny of expense unless he deemed it a success. On the other hand, I was so certain that I could fulfil these conditions that I risked the expenditure of £2,000 on a little central

station in his works, equipped, I remember, by a little Peter Brotherhood direct acting engine. So successful was the experiment that within three days of the turning on of the light, Bolckows were wiring all over the country for rail straighteners so as to make up extra shifts, and within six months I was engaged in applying the light to almost every rail bank in the Kingdom.

In October, 1881, I laid down a miniature central station to deal with the public lighting of the town of Chesterfield, and for the first time, I believe, arc and incandescent lamps were fed from a high tension circuit. The continuous current generator worked up to an E.M.F. of 2,000 volts at full speed with an output of 10 amperes. The arc lamps were run in series, and the incandescent lamps in series—parallel of eight lamps thus :—



The speed of the engine was varied by the number of arcs, or of groups of incandescent lamps on the circuit. Obviously, if one group burnt up without the automatic cut-out coming into operation, the whole of the town was plunged into darkness, but fortunately such a catastrophe never did occur.

In 1881 I erected a small central station in York. The British Association met there in that year, and Yorkshire being my adopted county through my long residence in Middlesborough, I made an offer to illuminate the city gratuitously with the electric light. My offer was accepted by the Council, and two nights before the opening day we had a most successful trial of the lamps dotted about all over the city. The next day, however, during a trial run, Sir John Lubbock, the President of the Association for the year, inspected the meeting hall, the platform, &c., and as he strongly objected to the buzz of our plant, erected in the garden, we were informed politely but firmly that the plant could not possibly be permitted to run. Fancy going to the expense of wiring a city, and laying down a central station out of pure enthusiasm, and finding one's work absolutely nullified at the last moment! Fortunately a sympathising citizen offered us another site, and, between noon one day and 6 o'clock the next evening, we dismantled the central station and re-erected the plant half a mile off, carrying out the public lighting of the City as on the opening evening.

Cockermouth, too, was the site of an early central station, this being put down for the public lighting of that town in 1881. I had undertaken this contract, and in the dearth of capable assistants that then reigned, I was at my wit's end to know who to send to superintend the work on the spot. At this juncture a man entered with a letter of recommendation of a flattering nature. "Could you go to Cockermouth by the 3 o'clock train," I asked. He replied in Yankee drawl, "Waal, I went to Singapore at four hours' notice, and I guess I could go to Cockermouth at five." Whereat he was dispatched and for some weeks we were in receipt of glowing reports of progress and applications for funds. On the eventful opening night excursion trains ran in from all parts of Cumberland, and the town was *en fête*. A switchboard was arranged outside the building so that the switching-on could be done in the sight of all the people. Mrs. Whittle, of Whitehaven, stepped forward to operate the switch, but, alas, no light came. When they sought for the "electrician" it was found that he had decamped, leaving a goodly amount of debts unpaid, and the arc lamps all connected up the wrong way. The crowd took the fiasco most good humoredly and amused themselves by parading the streets with lighted brooms dipped in tar, shouting "The only genuine brush light."

Another central station of the early eighties was that started in Holborn, in a yard in Whetstone Park, Lincoln's Inn, for the purpose of supplying arc lights to the neighbouring tradesmen. To-day the passers by will note that it is still one of the most brilliantly illuminated parts of London.

The modern electrical engineer, however, may be inclined to deny the right of any of these installations to the title of central stations, and desire to limit that title to works forming the centre of the system of mains feeding both incandescent and arc lighting circuits, and dealing with private rather than with public lighting. From this point of view, the honours of the title of "first central station" in the United Kingdom must be divided between the Holborn Viaduct and Brighton Works, both of which were established in the year 1882.

The Holborn Viaduct station was established by the Edison Company, chiefly for the purpose of demonstrating the value of the Edison incandescent lamps, and the supply was started early in 1882, but, owing to defective machinery and unreliable lamps, the station was not successful, and it disappeared in the course of a year or so. The Brighton station had a much longer experience, and its history dates from the winter of 1881. At this period a Health Exhibition was organised at Brighton, and I exhibited a set of plant there under the care of a very promising Hanover Square student, who has since become well-known in the electrical profession—Mr. Arthur Wright. At the request of certain Brighton tradesmen I did not remove the plant from Brighton, but had it laid down on a permanent basis at Read's Foundry, in the Gloster Road, where the public supply was inaugurated in February, 1882. This plant formed the nucleus of a central station, which pioneered the electric light for 13 years, from 1882 to 1894, when the business was absorbed by the Brighton Corporation. As the venture was started before the passage of the Electric Lighting Act of 1882, no statutory powers were available for the original Brighton Company, and it carried on its business for several years by means of bare overhead wires, charged with an E.M.F. of 2,000 volts, a state of things alarming to contemplate in the present day. Eventually, however, the bare wires were all replaced by insulated cables, run overhead. It was here that Mr. Arthur Wright perfected the parallel series system of running incandescent lamps, which was first used at Chesterfield.

A central station was started at Colchester in 1884 to work the B.T.K. accumulator system under the guidance of Mr. George Offor. The distinctive feature of this system was the use of secondary accumulators placed in batteries on the line of mains for the purpose of keeping the sectional diameter of the cable at a low limit. The accumulators were charged from high tension dynamos at a central station, and rocking switches, actuated by a special master cell, controlled the cutting off of each battery when the charging was completed, and, by the same operation, shunted the stored current on to the supply mains. At the same time the rocking switch transformed the high tension charging current to the standard E.M.F. required by the lamps in use. For this purpose, alternate groups of batteries and switches were utilised, so that while one battery was under the charging process, the other battery was supplying energy to consumers, though at the time of maximum load, both batteries could simultaneously feed on to the supply mains. The system involved too many complications for the economical supply of electricity to any extent, and the measure of success at Colchester never became full, though Sir Michael Kennedy, Mr. Offor, and Mr. King laboured hard in its cause.

Central town lighting stations, as the titles then ran, were also established on small scales at Bradford, Peterborough, Worcester, Tynemouth, and Portsmouth, and other places; but in due season they went the way of all things, their lives being short and, in some cases, not altogether happy. All the central stations that I have so far referred to, gradually disappeared; and, perhaps with the exception of that of Brighton—the first to come and the last to leave of the *un*-statutory pioneers—have long since been forgotten.

I have now reached the period when I can refer to these pioneer central stations which have survived to the present day. These are :—

Name of Place.	Year of Opening.
Eastbourne	1882.
Hastings	1882.
Liverpool	1883.
Kensington and Knightsbridge ...	1886.

I was personally responsible for the first two. In the case of Hastings we distributed the energy by means of overhead wires, but at Eastbourne we inaugurated the system, since become so general, of distributing energy at high tension for incandescent lighting over a large area by means of underground mains.

In those days there was a very hazy idea as to the powers of local authorities in reference to granting the use of their roads for the laying of electric light mains, some town clerks urging that they had the power to do so, while others, with more astuteness, denying the right. The latter argued on the lines that the local authorities' rights over the streets were strictly limited, that they were enabled to take up streets for the purpose of repair and for inspecting the water pipes, and, when acting as the water authority, for laying the water pipes, but that they could not give permission for the laying down of electric lighting cables because the owners on each side of the street owned the soil right up to the middle of the road. An old Roman law, which exists at the present day, establishes this and not merely this, but also by the *ad cœlum* law the owner possesses the right of property from the centre of the earth on which his house stands to a corresponding spot in the heavens. It has, I think, been held to be good law that local authorities hold the streets only on fief and had no further rights than those laid down by Act of Parliament. If, therefore, local authorities ventured to lay down mains or to give these rights to others, it was clear that any owner could have brought an indictment against them to prevent the mains being laid. This was an extremely awkward decision for those of us who were anxious to lay down electricity supply mains; but at Eastbourne it appears never to have entered into the heads of the local legal authorities that an agreement permitting the use of the roads for the laying of mains, other than those necessary for the lighting of the streets, was illegal. An agreement was accordingly entered into with the Electric Light Company, giving them that permission to open the roads, and under this *ultra vires* agreement the company worked till 1890, when it obtained its provisional order. Starting by supplying over an extended area with high tension, the parallel series system was adopted for the incandescent lighting; this risky system the company continued for some years. The danger to guard against was the extinction of one lamp in the group of ten, which extinction immediately increased the current going through the remaining nine from 1 ampere to 1.11 ampere. This danger was guarded against by the insertion of an automatic device, by the operation of which the extinction of any lamp in the group brought a safety lamp into work and so protected the group until a new lamp was inserted.

Mr. H. M. Sayers was the first engineer at Eastbourne. He recently had charge of the Bournemouth Works, and is now the chief engineer of the works laid down by me for the English Company in Madrid. We have therefore been in electrical connection for 16 years. The original generating plant consisted of Brush arc dynamos, driven by semi-portable engines. When the Town Hall was opened in 1886, we laid down a Lowrie-Parker Alternator, and supplied the light by means of Lowrie-Hall Transformers, made at the Eastbourne Works, and it was the success of that lighting that gave the death knell to the old group system at Eastbourne. At one time the prospects of the Eastbourne Company looked very dreary, and the local directors threw up the sponge. Having firm faith in the central station idea, and perhaps a certain amount of sentiment about one of my surviving central stations, I stepped into the breach, and, with the co-operation of a few friends, ran the undertaking for some years, and handed it back to the very contented directors as a going and paying concern. Except in respect of my titular consulting engineership, my connection with Eastbourne has long since ceased, but I am glad to note that, under the capable management of Mr. H. W. Wilkinson, regular dividends have been paid, the distributions for the past three years being at the rate of 7½ per cent. per annum.

On the pioneer works at Hastings I need not dwell, for to these works applies much of that which I have written in reference to Eastbourne. The same system of generation was used at the beginning, but the distribution was by means of overhead wires. The cables are now underground and the alternating current transformer system has, in the natural course of events, displaced the old group system.

Between the inception of the Eastbourne and Hastings schemes and the opening of the next pioneer central station, that of Liverpool, a very important event happened, viz., the passing of the Electric Lighting Act of 1882. Under this Act, the industry of the generation and distribution of electrical energy acquired a statutory status, and promoters of undertakings were given permission to use public roads under either a license with a tenure of seven years, or, a provisional order with a tenure of 21 years, the latter period being subsequently, by the Act of 1888, increased to 42 years.

The promoters of the Liverpool works, although as enthusiastic as other pioneers, did not allow their enthusiasm to overrule their prudence. They waited till they could obtain statutory status, and, as soon as the first Electric Lighting Act was passed, they obtained a license giving them a seven years' tenure. This license, fortunately for the Liverpool Company, was in 1889 extended into a Provisional Order. It has always been a matter of marvel to me that anyone should ever have laid down electricity works with a tenure limited to seven years. However, the Liverpool Company, for reasons unknown to me, started operations under a License. Guided by Mr. Bromley Holmes they adopted the low tension system with a standard pressure of 110 volts, and laid the mains underground. They were therefore on solid ground from the beginning, and the undertaking was financially successful from its first year. It paid a dividend on its first year of working and continued doing so annually till the undertaking was bought up in 1896 by the Liverpool Corporation, who paid £400,000 for the business which had cost the company £264,000 to establish. It is superfluous to explain to English readers that the purchase price was arrived at by agreement and was not compulsory, each undertaking possessing a Provisional Order being beyond the bounds of compulsory purchase by the local authority for a period of 42 years from the date of issue of the Order.

The original Liverpool works were equipped with Lancashire boilers and horizontal high pressure engines, with belt driven dynamos, but in the early extensions, Willans engines and direct driven dynamos were adopted, a type of plant that has been adhered to in all subsequent extensions. The mains consisted of Callender's solid system from the first. The price charged at the start was 1s. for the first 100 hours of maximum demand; 8d. for the next 100 hours, and 4d. for all further consumption.

The last of the strictly pioneer works were those laid down by Mr. R. E. Crompton at Kensington Court. I remember the builder of Kensington Court once remarking, "Your electricians seem ready to supply everything connected with electricity except light. I can get any number of dynamos, engines, patents, and lamps, but what I want for my buildings is light." I don't know the history of the foundation of the Kensington Court central station, but possibly Mr. Carr made a similar remark to Mr. R. E. Crompton, who replied, in his usual practical way, by laying down the Kensington Court works.

The original works consisted of a shed with a Marshall boiler and one of the old pattern Willans engines, which was lent by Willans and Robinson pending the completion of a central valve engine, which was late in delivery.

This engine arrived in the course of 1888, and was a single column engine of the G size, and also was, I believe, the pioneer engine of the central station plant now supplied by that firm. The mains in Kensington Court were laid in a subway, to which access could be got from all the houses, and as soon as the license was obtained extensions of mains were laid underground in the neighbouring streets.

The original operations were conducted under a license for seven years, which, on the passing of the amended Electric Lighting Act of 1888, was replaced by a Provisional Order.

Three other metropolitan works were started under the 1882 Act, viz., those at Chelsea, Whitehall Court, and St. James's. The main object in starting the Chelsea Company was to exemplify the latest example of the high tension accumulator system, and the Whitehall Court installation, since absorbed by the Metropolitan Company, was started to supply light to the block of buildings of that name. The St. James's Company was genuinely started as a central station, and has grown into a magnificent concern, though at the outset it met with indifferent success, and at one time could have been bought for an old song.

The development of electric lighting in London was largely assisted by an enterprise, the fortunes of which have been of peculiar variety. In 1885, Sir Coutts Lindsay laid down an installation in Bond Street to light the Grosvenor (picture) Gallery, and being applied to by some of the neighbouring tradesmen, he turned his attention to public supply by means of overhead wires. The system of distribution was quite novel, then known as the Gaulard & Gibbs system, and now as the Alternating Current Transformer system. Poor Gaulard, the patentee, who afterwards died in a madhouse, was a most excitable enthusiast, and at one point of his career he certainly imagined that in his "Secondary Generator," as he termed it, he had solved the perpetual motion problem. I remember his calling upon me at the time of my conducting some experiments with the first Ferranti Alternators under Cannon Street Railway arches, and declaring that with the semi-portable engine that we had there he could light the whole of London. He denied that the utilisation of the converted current had any effect upon the generating plant, and I at once suggested that it would be useful to fit up 100 E.H.P. of transformers in the arches, and run the alternator without the intervention of the engine. This sarcasm failed to shake his ideas, possibly because in my French it was somewhat veiled. However, his claims were so ludicrous that I declined to have anything to do with his system, a refusal which I afterwards had occasion to regret. Sir Coutts Lindsay made the first practical exhibition of it, but it went badly until, on the advice of Lord Kelvin, Mr. S. Z. de Ferranti was called in. He found the converters working in series and at once changed them to parallel working, which immediately proved highly successful. With the genius that has always characterised him, he completely transformed the Grosvenor Gallery station, putting in machinery of a much greater capacity. Customers came on with a rush and the business prospects were magnificent. A powerful set of capitalists came into the concern, boasted that they were going to freeze out every other concern in the metropolis, and started to erect works six miles down the river at Deptford and to equip them with plant of colossal size. Alas, for the uncertainty of human forecasts! Before they were ready to give reliable supply from Deptford, troubles arose from the overloading of their Grosvenor Gallery plant, culminating in a fire on the switchboard and a stoppage of the supply. The St. James's Company, operating in competition in the best part of their district, quickly snatched up the much-tried consumers, and the Deptford Company, after working a few years, and after having run through a capital of close upon a million sterling, finally went into the hands of a Receiver, who still retains possession of the undertaking, and who is working doggedly on in the hope of ultimately retrieving the fortunes of the concern.

The immense impulse, however, given by the Grosvenor Gallery Company to central station work was manifest in the keen competition for Provisional Orders for London districts immediately on the passing of the amended Electric Lighting Act of 1888, whereby the option of purchase by the local authorities did not operate until the expiration of 42 years, instead of the 21 years fixed by the Act of 1882. So numerous and conflicting were these applications that a public inquiry was appointed by the Board of Trade, and presided over by Major Marindin, assisted by Major Cardew. After a lengthy inquiry, at which the leading lights of both the engineering and legal profession were represented, the choicest parts of the metropolis were allotted to eight companies, viz., The Charing Cross, Chelsea, House to House, Kensington and Knightsbridge, Metropolitan, Notting Hill, St. James's and Westminster Companies, all of which are now working with excellent results.

As already pointed out as far as the provinces are concerned, Eastbourne, Hastings, and Liverpool led the way. They were followed by Sheffield in 1887, Taunton, Southampton, and Bradford in 1889, and Newcastle and Bath in 1890. The works at Bradford were laid down by Mr. J. N. Shoolbred on behalf of the Corporation of Bradford. These works afforded the first instance of municipal ownership of an electricity supply undertaking, and their marked success operated for a year or two as the one deciding argument for the repetition of the experiment in other places. The Brighton Corporation followed two years later, in 1891, with works also designed by Mr. Shoolbred, and in the same year the Vestry of St. Pancras started their first station at Regent's Park, these three undertakings being established under Provisional Orders granted as far back as 1883. The next municipalities to inaugurate electricity supply were those of Dublin and Nelson, their stations being opened in 1892, and these were closely followed by the municipal undertakings at Blackpool, Bristol, Burnley, Derby, Dundee, Glasgow, Huddersfield, Hull, Kingston-on-Thames, Lancaster, Manchester, and Whitehaven, all of which began operations in 1893.

In all these places companies had tried very hard to gain a footing, but without effect. They, however, secured a number of towns, including, in addition to those places already mentioned, Reading, Bray, Bournemouth, Birmingham, Chatham, Galway, Exeter, Fareham, Weybridge, Northampton, Leeds, Morecambe, Preston, Cambridge, Chelmsford, Oxford, Scarboro', Woking, Hove, Woolwich, Kelvinside, Killarney, Norwich, Ogmore, Pontypool, in all of which central stations were opened before the end of 1893. Since the year 1893 companies have had to content themselves with a very small proportion of the new undertakings, local authorities having very exhaustively taken the work out of their hands. This will be shown very clearly by the following table:—

CENTRAL STATIONS OPENED SINCE 1893.

Owned by.	Total for Four Years.
Local Authorities	44
Companies	13
Totals	57

Though it would be beyond the scope of my article to describe these works from an engineering point of view, I may point out that there is a very wide difference between the central stations of to-day and the pioneer stations out of which they have emerged. I think I can venture to assert, from an examination of central station work throughout Europe and the United States, that modern central stations in England represent the very finest practice in electrical engineering work.

Turning from the engineering to the financial side of the industry, I will content myself in conclusion by illustrating the progress of "central stations" during the past 25 years by a few statistics. In doing so I limit my attention to those which are working under the Electric Lighting Acts.

Statement of Financial Progress of Electricity Supply Industry for 25 Years.

Year.	Number of Central Stations in operation in United Kingdom.	Total number of lamps of 8 candle power connected.	Total Amount of Capital Invested.	Margin to the good between Revenue and Working Costs (exclusive of depreciation).
1873				
1874				
1875				
1876				
1877	nil.	nil.	nil.	nil.
1878				
1879				
1880				
1881				
1882	2	500	£8,500	For these years
1883	3	4,000	£18,500	no accurate
1884	3	6,000	£25,000	data of profits
1885	4	13,000	£30,000	are available.
1886	5	18,000	£45,000	Liverpool
1887	6	25,000	£60,000	Company
1888	7	50,000	£150,000	regularly paid
1889	14	100,000	£450,000	dividends from
1890	17	220,000	£650,000	1883.
1891	32	451,000	£2,950,000	£60,000
1892	41	664,000	£3,985,000	£124,000
1893	63	1,140,000	£4,195,000	£174,000
1894	85	1,713,000	£6,246,000	£275,000
1895	100	2,455,000	£7,808,000	£409,000
1896	113	3,244,000	£9,528,000	£580,000
1897	122	5,000,000	£11,500,000	£800,000

The figures for the earlier years are, of course, only approximate, it being impossible in the majority of cases, to secure accurate Particulars. For 1897 the figures are estimated.

Satisfactory as the progress has been in the past 25 years, I venture to prophesy that, in view of the almost infinite possibilities of the extended use of electrical energy, the contributor, to whom a similar task is allotted 25 years hence, will be able to record a progress of far greater magnitude than that which I have endeavoured to portray for the special number of the Electrical Review.

1831—1872.

By W. M. MORDEY.

As one who has taken the Electrical Review since its commencement, the writer joins with great pleasure in celebrating the completion of the 25th year of issue. He wishes to congratulate the editors and proprietors on the useful work they have done, and to record his obligations for the advantages he has derived from the regular perusal of their paper, and to express a hope that they may live to celebrate a second similar period of usefulness to the electrical world.

The stately array of volumes on the writer's shelves invites comparison between the first small volume covering the period from November 15th, 1872, to November 15th, 1873, and the later substantial half-yearly volumes. It is, perhaps, because they deal often with the work of pioneers, or it may be an effect of old age that gives the early volumes an interest even greater than the recent ones—it is certainly not from any falling off in quality.

The writer has been asked to write on alternate current work of the last 25 years, but he refrains. He believes the marvellous progress of those strenuous years will receive ample justice from other writers. He fears there may be a little danger of forgetting the period anterior to the last 25 years, and he therefore sends a few fugitive notes on the period leading up to the appearance of Vol. 1 of the Telegraphic Journal and Electrical Review in 1872.

We should have to go back much further than 25 years if we wished to trace to its infancy the practical use of alternate currents—possibly back to that historic picnic in 1748, when Benjamin Franklin "killed a turkey by the electric spark, and roasted it by an electric jack, before a fire kindled by the electric bottle." Surely the first recorded example of intentional "electrocution," and fittingly, the work of an American.

There is a common impression that the use of alternate currents for practical electric lighting is a very recent development of electrical engineering, but as a matter of fact (if we except voltaic applications), alternate currents have considerably greater claims than direct currents to be considered the older of the two. What is new, and what caused a revival of the use of alternate current working, is the transformer system, introduced when it was found necessary to have some readier way of covering large areas than that afforded by low tension direct current systems.

Practical and successful alternate current machines were in existence and in regular use long before direct current generators were developed—and some of those early magneto alternators are still working and giving a very good account of themselves for the purpose to which they were originally applied 40 years ago—that of electric lighthouse work.

The state of knowledge in 1830 may be best realised by Faraday's words in introducing the subject:—"The hope of obtaining electricity from ordinary magnetism has stimulated me, at various times, to investigate experimentally the inductive effect of electric currents."

The development of alternate current work was a natural outcome of Faraday's discovery of magneto-electric induction—that discovery was primarily the discovery of the mechanical generation of alternate currents, and all the experiments—with one remarkable exception—made by Faraday in that investigation, and all the results obtained by him were such as to lead directly to the construction of alternate current generators. But the discovery was a dual one, for as an immediate result of his success in obtaining alternate currents, Faraday invented, made, and tried a form of generator which provided a very complete solution of the problem of how to obtain a direct current mechanically. The Faraday disc machine gives the most perfectly non-pulsating direct current that can possibly be obtained. This Faraday disc or "unipolar" dynamo (as, in its modern form, it has been not very happily called) was described in the same paper as the discovery of magneto-electric induction (the first section of the "Experimental Researches," read November 24th, 1831), and was used to illustrate that discovery.

That so much ground was covered at one stride was probably in part an incidental or accidental result of the direction given to Faraday's thoughts by a phenomenon which happened to be attracting much attention at the time, Arago's experiment of the rotation of a copper disc caused by the movement of a magnet. One of Faraday's objects was the "Explication of Arago's Magnetic Phenomena." When engaged on this task, and having traced the cause of the rotation to the generation of alternate currents in the disc as a result of the movement of the magnet, it is not difficult to us now to see that Faraday would be led, by fixing the magnet and revolving the disc, to the induction of direct currents, and so to the production of a commutatorless direct current generator.

That brilliant direct current exception was in a sense barren, for it was to the alternate current discovery that we owe not only the development and practical use of alternate current work, but to the same source we must trace the modern direct current dynamo, for this machine has been evolved, by a slow and laborious process, directly from the alternate current discovery, and not in any sense from that first and (in many ways) perfect direct current generator. The Faraday disc and the principle underlying it does not now appear likely ever to become the ancestor of an important family, but it has a very great interest, and, perhaps, better than any other of Faraday's experiments in this field, it illustrates his wonderful intuition.

It is well to note the true pedigree of the dynamo. Although to the external world it appears as a direct current machine, it is in its heart an alternator, not only by inheritance but in actual fact—it is right that its true character should be known.

Between 1831 and the year when the Electrical Review, or its parent the Telegraphic Journal, came into being—1872—alternate current working was in possession of the

field so far as mechanical generators of electricity were concerned, but as an art it had not advanced very rapidly—although the records of that period of 40 years, show, in the bulk, an enormous activity in regard to modification of detail of magneto-generators. But people were working very much in the dark; they were working without any adequate methods of measurement. Although Joule's main work was done only eight or nine years after Faraday's discovery, ideas on the conservation of energy and on electrical equivalents did not become current till long afterwards, and real progress was delayed in consequence. It was not till 1858 or 1859 that Faraday's child, in Prof. Holmes's hands, became a man and proved its usefulness by successfully providing electric light for the South Foreland lighthouse.

From 1859 to 1872 progress in alternate currents was small in practical effect, so far as concerned the growth of this work as a branch of engineering. The advance in alternate current work was not great between 1859 and 1872, by comparison with the progress since 1872—Wilde did a great deal of work, but the practical effect was slight.

This is not to be wondered at when it is remembered that even in telegraph work—the most advanced branch then—things were done which would now be thought ludicrous. The present writer remembers, for example, using resistance coils of a few thousand ohms, weighing certainly more than 30 lbs.; they were made of copper wire of quite large diameter. These coils were, perhaps, required to carry a full load of possibly one watt. He also remembers that the mystic letters, "OHMS." on these coils was currently understood to mean "On Her Majesty's Service," and this was in '71 or '72.

One explanation or this comparatively slow progress was the absence of any direct current generator at all approaching in quality the then existing alternators. Electricians were accustomed to direct current work, so far as Bunsen and Grove and bichromate cells enabled them to go; the lighthouse alternators gave large currents, useful enough for the one special purpose—the running of an arc lamp; but at that time the knowledge of how to use alternate currents was very small. The necessity for lamination of magnet cores, low magnetic densities, and so on, although perhaps known to a few, was not common knowledge; economy of power was hardly thought of.

Placing commutators on the existing alternators was a troublesome way of getting direct currents, and people generally preferred to use their voltaic cells.

The best work, by far, was done by Wilde at Manchester; but although done within a short distance of the scene of Joule's labours, it does not seem to have been much influenced by them. One thing should be specially mentioned in connection with Wilde. Although the need to run more than one alternator at a time can scarcely have been very pressing, Wilde discovered in 1866 the synchronising and motor tendencies of his machines.

The period 1870 to 1872 saw the Gramme dynamo invented and introduced, and this gave a great impulse to the subject—the Gramme collector (previously invented and described in 1864 by Pacinotti—but then overlooked) turned people away from all their alternator-plus-commutator constructions. It is said that Gramme's original British patent, No. 1,668 of 1870, was sent out of Paris by balloon during the siege. If this is true, it affords another illustration of the influence of war in energising men's minds to the ultimate promotion of the arts of peace.

The Pacinotti-Gramme idea of a number of coils and of collector bars evenly distributed round a ring was a simple but most important step, for it turned people away from all their alternator-plus-commutator constructions; steady direct currents were made available, and a new era commenced.

Werner Siemens in Berlin, and Wheatstone here, had independently invented the self-exciting of dynamos. By one of those coincidences so common in the history of invention, each announced his invention on the same day (February 14th, 1867), one to the Berlin Academy, the other to the Royal Society. The result of all this was, that for some years attention was given chiefly to the study of direct currents; alternate currents went out of fashion, to come up again with renewed strength, their study being immensely facilitated by the knowledge gained by the consideration of direct current problems; but this renascence of alternate currents did not come till some years after the Review first appeared.

TWENTY-FIVE YEARS' RETROSPECT ON PRIMARY GALVANIC BATTERIES.

By T. E. GATEHOUSE.

Of all the subjects which form themes for special articles in this issue of the Electrical Review, the topic which the writer has chosen, upon which to string together a few remarks, is at once the easiest and the least satisfactory. In all the rest developments of considerable, and, in the majority of instances, extraordinary, importance, have characterised their progress during the past quarter of a century, but primary batteries, alas! stand in almost the same condition as they existed at the time of the Review's inception. During the greater part of the first decade batteries were used almost exclusively for telegraphy, and later for telephony, and it was only after the commercially successful advent of the electric light, that a real "boom" in galvanic elements arose; but these periodical developments were not in the direction of the economical generation of electrical energy, but in nine cases out of ten were nothing more nor less than "wild cat" schemes, unfortunately too often successful, for emptying the pockets of the gullible British public into the coffers of unscrupulous company promoters.

A primary battery, as distinguished from a secondary battery, is one in which the materials for generating an electric current are arranged in such a condition as to be at once available, whereas the elements of a secondary battery have to undergo modification by passing through them a current of electricity from another source, as, for instance, a dynamo, so producing electrolysis, before they are capable of giving out any electrical energy; some batteries may combine both characters in one, but of these it is not the writer's intention to dilate upon.

The most simple forms of primary batteries are very inconstant; the chemical action diminishes, the current rapidly decreases, and shortly practically ceases, a result due mainly to what is known as *polarisation*.

The first constant battery was that of Daniell, invented in 1836, and if we want constancy, we even now use a Daniell cell, or one of its many modified forms, some of which are good, others bad, and the rest indifferent.

Local action also has always been a source of trouble in primary batteries. Chemical action goes on when the cell is on open circuit; that is, when not connected up to any circuit for the purpose of sending out current, and this waste of material is called local action. It is always a considerable factor in the consumption of commercial zinc in acid solutions, as the zinc contains foreign matter, such as iron, carbon, &c. These form, with the zinc, local circuits, little galvanic couples, and the zinc is eaten away.

Amalgamation is intended to prevent this waste, and although it does not entirely prevent it, it reduces it in some cases to a very small percentage of the total consumption of the oxidisable metal zinc; but there are other forms of local action which amalgamation does not affect.

Take for example the old form of Daniell cell; copper is sometimes deposited on the porous jar instead of upon the copper plate. This deposit would at times fill up the pores and crack the jar.

Then the diffusion of the copper salt through the porous jar, when the battery is on open circuit, brings it in contact with the zinc; the copper separates in a finely divided state, and is usually oxidised and deposited on the zinc as CuO, hydrogen at the same time being given off. This is equivalent to local action.

From 1872, for a period of nearly 10 years, a number of honest endeavours seem to have been made to eliminate, or at least to minimise, the defects inherent to the then existing forms of primary batteries, and to the most important of these a brief allusion seems warranted.

The numberless inventions in the primary battery way for lighting and motive power purposes, the many reckless and dishonest attempts to delude people to the belief that electrical energy could be had for nothing, the bye-products from the exhausted cells being so valuable as to enable electric lighting to be thrown in, and the secret depolarising powders which so reduced the consumption of zinc as to make it a negligible quantity, came across the scene a little later and will be alluded to in due course.

Previous to 1872, the well-known elements of Bunsen, Grove, Smee, Daniell, the early form of Leclanché and the bichromate battery were in operation, and Sturgeon had given to the world the benefit of his discovery of the advantage to be gained by amalgamating zinc.

A glance at the first volume of the Review reveals nothing in the nature of improvements in batteries, nor does the second, although here we find a six-column report upon bichromate cells from the pen of the accomplished Count du Moncel. In 1875 Dr. J. H. Gladstone, F.R.S., delivered a course of six lectures "On the Voltaic Battery," but these dealt only with the theory of voltaic action, the effects which could then be produced, and the uses to which batteries could be put.

In 1876 there appeared in our pages a brief note descriptive of Leclanché's improvement of substituting the agglomerate blocks for the porous pot and its contents, but this was not fully described and illustrated till 1876, in Vol. 7.

It may be interesting to state here that this cell, which for many purposes has proved itself to be eminently useful, and which at the present day is perhaps more used than ever, was patented by M. G. L. Leclanché in 1866. The rod form now largely used by the Admiralty, War Office, and Post Office, was designed by the Silvertown Company in 1877. This arrangement permits of freer circulation, and, from its shape, offers a larger surface for depolarisation.

In 1877 we described and illustrated Mr. John Fuller's mercury-bichromate battery. Mr. Sivewright, speaking of the old bichromate of potash battery in his paper, "On Batteries and their Employment in Telegraphy," read before the Society of Telegraph Engineers about the beginning of 1875, says: "*The amalgamation of the zincs, a point of vital importance in both this and Grove's battery, had constantly to be seen to.*" Mr. Fuller (doubtless taking a lesson from the late C. V. Walker, F.R.S.), recognised the "point of vital importance," put his zinc in a porous tube containing about an ounce of mercury and filled up with water, and so kept his zinc *permanently* amalgamated so long as it lasted. Nothing could be more simple than this device which certainly rises to the importance of a real invention, and Mr. Fuller long ago reaped to the full, and rightly so, the reward which he so richly merited, and the battery is, we believe, still very extensively employed in the English Postal Telegraph system.

In the case of the bichromate batteries used by the Exchange Telegraph Company, and which, for their class, are cheap and reliable, perhaps the company's practice may be found of interest:—

1. The substitution of bichromate of soda for potash enables the solution to be made of greater strength and in far less time, by reason of the greater solubility of the soda salt, while at the same time the deposit of chrome alum is avoided.

2. The zinc plates being impregnated with mercury, only require amalgamation lightly at the outset.

3. The use of an iron connecting wire from the top to bottom of zinc ensures that no interruptions shall occur from breakage of the zinc element through irregular consumption. There is also the advantage that the elimination of the copper connection removes the local action caused by the metallic copper from the copper salt being precipitated in needle form in the mercury. Local action not only destroys the zinc and wastes the solution in which it is immersed, but ultimately the excess of hydrogen causes the deterioration of the chromic acid.

4. The use of semi-vitrified porcelain, with its numerous very minute pores, instead of the pumice-like pores of some kind of ware, gives low resistance with the minimum of transfusion.

5. The carbon plate is waxed to a line below the surface of the liquid, and allowed to nearly cool in the wax, thus filling the pores and preventing the creeping up of the solution, and consequent destruction of the contact.

6. The size used has a difference of potential of from 1·8 to 1·9 volts, and internal resistance of 0·5 ohm, and during working affords about 25 ampere-hours of current at a cost of 2d. for the charges of acid.

All these improvements in details have been devised by Mr. F. Higgins, the company's engineer, and are the results of long and patient investigation.

At the beginning of 1878 the chloride of silver cell of Mr. Warren de la Rue for testing purposes on shore and at sea is described and illustrated, and on March 1st there appears a paper, read by Dr. Lodge for its author, Mr. H. F. Morley, before the Physical Society, on "Grove's Gas Battery." The gas battery seems to offer a promising field for further research, but nobody appears to have directed any particular attention to it.

On April 1st the published *Proceedings* of the Society of Telegraph Engineers deal with the before-mentioned chloride of silver cell, and Dr. Byrne's pneumatic battery. This was a modification of the bichromate type, in which air was forced into the electrolyte by means of a bellows communicating with a perforated tube inside the cells, a most remarkable rise in the current strength being the result. Much was expected from this, but it came to a premature end almost as soon as conceived. An illustration of this cell may be seen in the Review for June 1st of the same year, together with a critical article upon it from the pen of Mr. F. Higgins. Then on July 1st Mr. H. R. Kempe describes a portable form of Byrne's battery devised by himself.

In the February 1st issue of 1879 Mr. Higgins writes on the effects of amalgamation, and on November 15th there appears a description of Alfred Niaudet's chloride of lime battery, a remarkably cheap and efficient cell, which might with advantage be revived for a variety of purposes. On December 1st Howell's battery, a form of peroxide of manganese and ammonia element, with zinc and carbon plates, is illustrated; this, from the exhaustive tests made by the late C. F. Hockin, which are published in the succeeding issue, seemed to be superior to any other battery then known for telegraphic purposes; but nothing came of it, so far as the writer is aware. 1879 seems to have been a year of rest to the primary battery inventor.

In January, 1880, the bye-product man appears. A Mr. Slater exhibited in Cheapside a nickel-carbon battery, and it was hinted that for an outlay in chemicals and metal amounting to £4 10s., the sulphate of nickel would yield a return of £17 10s., deducting from this the cost of the plant, labour, waste, &c. It was stated, even allowing for this, Mr. Slater's invention appeared likely to be a highly profitable one. One cannot help paraphrasing Hans Breitmann, and ask, Where is that invention now?

It is interesting to observe in the same issue a description of Edison's carbon filament lamp and electrolytic cell meter, and also a vigorous protest from the Count du Moncel at the excitement caused in the money market on the announcement of Edison's discovery. "Edison," says the writer, "is an ingenious and fertile inventor, but is not acquainted with the discoveries made before his time. His first lamp was a modification of the one invented by Changy in 1858; the one now announced is the modification of those of several inventors."

On June 1st, we find a notice of R. C. Anderson's battery, a zinc-carbon arrangement excited by a mixture of muriatic acid and bichromate of potash, with the addition of a small quantity of *patent compound salts!*

Following this, we come across, in the month of August, a long account of a "new, powerful, and constant battery, without acid," by Emile Reynier. The zinc was plunged into a solution of caustic soda, and the negative copper is depolarised by a solution of sulphate of copper, separated from the alkaline solution by a porous cell. M. Reynier diminishes the resistance of the solutions by adding certain "selected salts."

This battery compared favourably with the well-known and powerful types, and was of the kind which could be regenerated by sending a current of electricity through the exhausted liquids. For a time the nature of the certain "selected salts" was kept secret, but later it came out that, amongst other things, the inventor used 20 parts of kalium chloride (another name for chloride of potassium), 20 parts chloride of sodium, and 20 parts of *common salt:* which, of course, is the same thing as chloride of sodium. So much for M. Reynier's chemistry. With this, the galvanic batteries of any importance during 1880 appear to end.

In 1881, Maiche's battery appears in the issue of April 15th, but this of no great value except for bell ringing, &c., although it is prettily devised.

With this volume the fortnightly issues of the Electrical Review terminated, and, from the commencement of 1882 until to-day, it has been published weekly in its pre-

sent guise. The "boom" in primary batteries did not make any great headway for several years, as in 1882 we find notice of only two or three improvements in the production of electricity by chemical action; nevertheless there were occasional outward and visible signs of which way the wind was blowing. The first of these is the American preserved meat can cell of A. R. Bennett, which could be made up at a total cost of 6d. per cell. With a few of these it was suggested a man might light his library, drive his wife's sewing machine, and with the bye products paint his house or a part of it.

About the middle of the year there was issued the prospectus of the "Self-Generating Electric Light and Power Company, Limited," in which the impudent claim was made that with a few Bunsen cells a Mr. Simons was prepared by the mysterious agency of a secret powder to light up houses at a mere nominal cost, the zincs in his batteries being effectually preserved. This pretty scheme did not go much beyond the issue of the prospectus.

We next come, in 1883, across Trouvé's bichromate of potash battery, with results of experiments made by Prof. Hospitalier upon two sets each containing six elements; the figures obtained allowed of easily calculating the cost of disposable electric energy. In July and August of the same year is described the new oxide of copper battery of De Lalande and Chaperon, which Edison afterwards took in hand, and which has since been known as the Edison-Lalande element. Considerable interest was evinced in this battery from its birth, but the electromotive force of the combination is too low (a little over half a volt) and even Edison could not alter that, although he improved it in other ways. This is also a reversible or regenerative form of cell.

In 1884 was ushered in the Ross primary battery, upon which poor Fred. Ormiston made such a mistaken report. The consumption of zinc per E.H.P. hour was, according to him, only 11 to 12 ozs., an impossible result, and the error was due, if the writer's memory is not at fault, to taking the difference of potential on open circuit instead of the working E.M.F. when the battery was producing a current of 12½ amperes during a run of 13 hours.

A description of Jablochkoff's new battery appeared in our pages on November 1st. It was a sodium-carbon couple, and its action was dependent upon the affinity of the sodium for oxygen. Such a battery acts so long as the air is moist; but although the E.M.F. was high, so was its internal resistance, and for all practical purposes it was of no avail.

In May, 1895, the following note appeared in the Review:—

Jablochkoff's New Battery.—A most laudatory article on this new battery—"auto-accumulator," the inventor calls it—recently appeared in an English journal of the highest repute, and we fear that in some minds considerable misunderstanding; not to say misplaced confidence, in the new idea will result therefrom. So far as we can judge, this triple electrode battery is about as valuable a production as the same inventor's electro-motor, which is well known as the most inefficient of all that have yet been tried. We shall endeavour in our next issue to show that this apparatus, which is said to produce 1 horse-power-hour of electrical energy for one halfpenny, is, if not a retrograde movement, no advance in primary batteries.

This battery, it must be understood, was intended to be an advance on the sodium-carbon couple, and was fully described in the following issue of the Review, and on June 20th and 27th the writer gave the results of the experiments he had made, and the Jablochkoff marvel went the way of all things; a leading article, also from the writer, on July 25th, concluding the Review's comments on this impracticable, yet to some folks, plausible, scheme.

In our pages for February 12th, 1886, there appears an article by Dr. Oliver Lodge, which primary battery enthusiasts might still peruse with advantage. It is entitled, "On the Running Down of Batteries as Influenced by their Performance of Mechanical Work."

In June, Mr. Upward gave publicity to his "chlorine" battery. The energetic action of chlorine in a gas battery was pointed out by Grove long before, and several inventors had attempted to construct batteries on somewhat the same lines as those followed by Mr. Upward, but apparently without any success. So far as the writer is aware, Mr. Upward's battery never came into practical use except in one or two instances, for the objections to its employment probably outweighed the economy it seemed to show in the production of electrical energy on a large scale.

The issue for July 30th is full of interest for those to whom these lines are mainly addressed, for herein we find a report, and such a report! on the Maquay battery from the pen of the irrepressible Mr. Sydney F. Walker, a description and illustration of the cell, and a slashing criticism of Mr. Walker's report. A note from the same issue may be worth reproduction:—

Mr. Sidney F. Walker suggests in our "Correspondence" columns that the standard E.M.F. of batteries should be that measured on open circuit. When the E.M.F. of various cells are compared, the measurements are always so made, but this free potential must not be taken as the E.M.F. of the battery when connected up and doing work. As an instance, let us suppose that a battery indicates 50 volts on open circuit. If, now, we set it in action with an external resistance equal to its own internal resistance, the difference of potential at the terminals, or the working E.M.F., will drop to 25 volts. It is, then, this last figure which, multiplied by the current, gives us the electrical energy developed in the external circuit. Unfortunately, it often happens that the free potential of the battery is used for making these calculations, instead of the difference of potential at the battery terminals *when in operation*; a fictitious value is thus given to the battery, which leads only to disappointment in actual practice.

On Sept. 3rd we severely criticised the prospectus of the Regent Portable Electric Lamp and Lighting Company, in which the capital to work the Maquay battery is coolly fixed at £75,000. To an eminent professor, who was the consulting electrician of the company, and who reported so favourably on the strength of a laboratory test, this would form interesting retrospective matter. One of the claims in this precious patent was for a method of amalgmating the zinc already known and used years previously. A desultory correspondence was carried on for a brief period and—exit Maquay!

A short article published on March 25th, 1887, on "Local Action in Batteries," by Mr. W. Moon, is well worthy of bearing in mind, and in the middle of June, a Mr. Newton was introduced to the public as the inventor of a battery consisting of a zinc positive, iron negative, with a caustic alkali as exciting fluid and oxide of lead as depolariser. The advantage claimed was the valuable bye products which could be profitably reclaimed, but one never heard of this being done.

In the volume for June to December, 1887, will be found D'Humy's "Water" battery, the "Eclipse," and others. The first of these, an iron-carbon arrangement, with nitric acid in one compartment, and water in the other, separated by a porous partition, created great excitement. It was stated, with what truth the writer is unable to say, that a hidden gas engine and dynamo played no unimportant rôle in the marvellous output of this crude and senseless device, and it is a question whether D'Humy and his supporters, or the "Eclipse" fraternity should be awarded the merit of putting Ananias absolutely in the shade.

On June 22nd, 1888, we chronicled a real advance in primary batteries of the Bunsen type, invented by M. Weymersch. The writer made exhaustive trials of this battery, both at the time above mentioned, and in June, 1890, and he does not know of anything which has yet equalled the results then obtained. The Silvertown Company has for some ten years past supplied a fairly efficient low resistance cell, somewhat similar to that of Weymersch, which once upon a time the company manufactured. It is only fair to add, however, that their own form of battery was in existence before the advent of Weymersch. Weymersch, it may be mentioned, thoroughly understood his subject, knew what other investigators had accomplished, and claimed nothing for his battery which the tests did not bear out.

Although smaller fry followed in the wake of Mr. D'Humy and the inventor of the "Eclipse," there is no need to make any particular reference to these, and for several years there was a comparative lull in the primary battery market.

We described and illustrated on March 17th, 1893, the Leclanché-Barbier cell, an excellent example of its kind, and on September 21st, 1894, the Velvo-carbon battery, to all intents and purposes a Smee. On January 18th, 1895, appeared the Walker-Wilkins battery. Many misleading and untrue claims were made for this pile, in which the writer has failed to discover anything novel.

Then followed the "Milver" or Levetus cell, the "Excelsior," and, lastly, that most stupid of all latter-day absurdities, the McDonald battery, which was stripped of all

its garnish in the Review for November 20th and 27th, 1896. This, like most of its predecessors, was to revolutionise the production of electric energy; houses were to be lighted by its agency, motor cars driven, ships propelled and what not, but none of these things have come to pass. Like every dog, they have their day, and one could justly add sufficient for the day is the evil thereof, for the usual result seems to be the transference of cash from the pockets of those who can oftentimes ill afford to lose it, to the rapacious maws of company promoters and unscrupulous speculators. Unfortunately there are a certain number of well known professional men ever ready to give glowing reports on inventions which they *know* to be worthless, and much of the mischief done is to be clearly traced to this unworthy practice.

Of Clark's standard cells and Lord Rayleigh's tests, of the Board of Trade standards, Carhart's, Fleming's, and other designs of standard Daniell galvanic elements, there is no opportunity of speaking, nor of gravity Daniell's, Thomson's tray Daniells, Mond and Langers, and other gas batteries, Borchers's fuel battery, Jacques's carbon generator, &c.

Doubtless inventors and manufacturers believe the introduction of the dry cell has given a new lease of life to the primary battery, and that it is as yet too little appreciated by the general public.

The difference between the various dry cells of Lessing, Obach, Hellesen, &c., which have from time to time been placed on the market, is less one of principle than of attention to details of construction and care in manufacture, and this chiefly accounts for the great difference in efficiency and durability of the various kinds.

Of course, numerous minor improvements in the construction of galvanic batteries have been made, such as, for instance, a better contact between the carbon electrode and the brass terminal, and Dr. Obach has introduced an "expanding alloy contact" for this very purpose (see Patent No. 14,846, 1896), which is in use in the dry cells made by Messrs. Siemens Bros. & Co., and has given very satisfactory results. Indeed, this alloy contact may be very usefully employed for any other battery having carbon or other non-metallic electrodes, viz, in the case of ordinary Leclanché or Fuller's cells. Dry batteries, however, have the disadvantage of giving out without sufficient notice.

On the other hand it is thought in many quarters that since the introduction of secondary batteries the primary battery has lost much of the practical interest which was previously attached to it, and some of those who formerly went deeply and intelligently into the subject have given up all hopes of the discovery of any form of primary battery which shall be an economical generator of electrical energy. One of the writer's friends has said that he cannot imagine a better means of disenchantment as to the efficiency of primary batteries than employing them for the purpose of recharging storage cells. The writer is thoroughly sceptical regarding nearly all the alleged improvements, for none of them, except for a few special purposes, appear to equal an accumulator; at the same time he feels that there are fields for research in the galvanic or chemical production of electricity which have not been yet thoroughly explored. For the economical production of electrical energy zinc is too dear, but it may become less costly, and the direct production of electricity from coal is exercising many minds.

The space at the writer's disposal has not allowed of the mention of every genuine suggestion towards the evolution of an ideal primary battery, and there are probably certain omissions of bare-faced schemes to fleece the public, but enough has been said to show that the subject is one possessed of great fascination, both to those of an inventive turn of mind, and the capitalist. Unfortunately 75 per cent. of the men whose names are associated with primary batteries never studied the essential features which galvanic elements should possess, nor have they seemed to be aware of the defects inherent to nearly all of them which had to be overcome, and their ignorance of the researches of previous investigators has been simply lamentable. In the early days this was not the case; Wollaston, Grove, Bunsen, and Daniell, were all men of high scientific attainments, and the most eloquent testimony to their inventive skill and rare knowledge of galvanic electricity is shown to-day in the fact that we have nothing better to put forward. Jacobi, 59 years ago, ran his boat on the Neva with primary batteries, and last November, just a year ago, the secretary and solicitor to the McDonald Patent Battery Syndicate wrote to us "With a view of demonstrating the applicability of the battery for the propulsion of vessels, the Syndicate recently purchased the steam yacht *Medusa*, between 50 and 60 feet long. She is being fitted with batteries and motors and we expect her to be ready for her trials in about a month"; but we have not yet received an invitation to be present at the trial trip!

One would think that the very first and absolutely necessary research for a would-be primary battery inventor to undertake is a thorough and exhaustive dive into the archives of the Patent Office to ascertain whether his ideas had been anticipated, but judging from the constant resuscitation of old, forgotten, or abandoned combinations, this seems but rarely carried out, or, indeed, deemed worth consideration. And yet what valuable time and large sums of money could have been saved by such a simple process. To think that a patent agent would do this for him before a patent has been applied for is expecting too much of human nature, as in nine cases out of ten the agent would find himself in the same unpleasant position as the Moor of Venice when his occupation had gone.

Moreover, he would scarcely go back further than 14 years, the period for which English patents are granted, and almost every conceivable combination of known chemicals and metals had been tried earlier.

The history of all sorts and conditions of primary galvanic elements is writ large in the volumes of the Electrical Review, and from a careful study of its pages one can at least learn what to avoid and what not to patent. Failing this, the writer would strongly urge upon all inventors the desirability of becoming thoroughly acquainted with the contents of the late Alfred Niaudet's "Electric Batteries," and Prof. Carhart's very able treatise on "Primary Batteries."

ELIESON ELECTRIC MOTOR CAR AND THE LAMINA ACCUMULATOR.

One of these cars having now been running for some months past, a few details will doubtless be of interest. For general design we refer our readers to the accompanying illustration.

The frame is composed of Manessmann steel tubes. Thus not only are great strength and rigidity obtained, lightness also is secured. These frames are built by Mr. John Warrick, of Reading, maker of the "Monarch" delivery cycle.

The motor is suspended underneath the car from the tubular frame. The most novel point about the car is the gearing. A chain is used to transmit the motion of the motor to the driving wheels of the car. This chain gears with the teeth of a sprocket wheel on the motor spindle, but one of the rivets in every third link of the chain is substituted by a pin which stands out about an inch on either side of the chain.

Now, round the periphery of the driving pulleys (fixed one on each hind wheel of the car) two bands of leather are fastened. These bands are placed the width of the chain apart.

The chain runs between these two bands, while the pins grip on the leather. A most absolute grip is obtained by this means. This gearing is said to secure what no other gearing has ever before attained, namely, the combination of a positive driving, with the advantage, hitherto peculiar to belt driving alone, namely, that in turning corners, it permits slip to take place on one side; for, when turning a corner, one wheel is checked, the other revolves at its normal speed, the chain slips on the former, but as soon as it is required, revolves it by friction like the others. Some may think that a slip will take place when not required, such as when ascending steep hills. This matter has been fully tested by ascending Haverstock Hill at a very good speed. The steepest gradient on this hill is 1 in 15, others being 1 in 18; 1 in 25; 1 in 29; 1 in 34; length, 3,750 feet.

By this arrangement of chain-belt gearing, differential gear is dispensed with. This is an extremely important

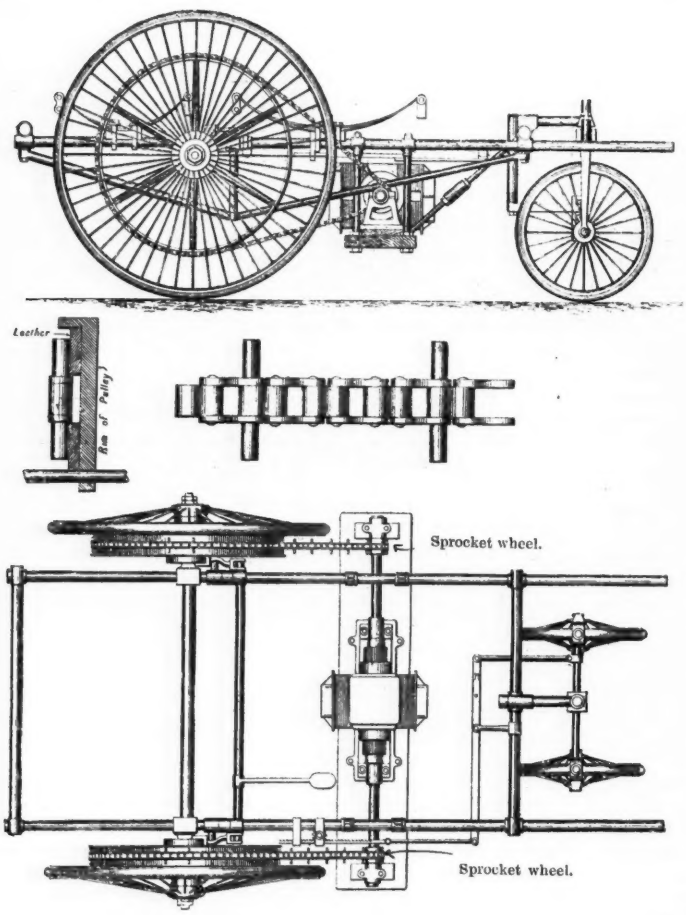
point, as it reduces the number of working parts to a minimum, also simultaneously reducing the possibility of getting out of order. Further, it is a remarkably silent form of gear. The inventor's chief aim has been to simplify and reduce the working parts of a motor car, so that it should not be an object of mystery to its owner.

There are five fixed grades of speed, but, of course, any speed may be obtained.

This special type of car is intended for City use. A man living 5 or 10 miles out of the City could drive into the City in the morning, and whilst engaged in business his car is being charged.

This charge is sufficient to carry him home and into the City again the next day. Thus the owner of the car need not have a supply of electricity at his house. The company is proceeding with the construction of vehicles of other descriptions, but anticipate a very large demand for these little cars, and even a greater demand for their small vans for the delivery of parcels. No difficulty whatever has been found in manipulating this car in the thickest City traffic, journeys being made almost daily from the works, Camden Town, to the Bank, *viâ* Oxford Street, Holborn and Cheapside.

Energy is supplied to the motor from a battery of Lamina accumulators, which permit of a run of 30 miles to be made at an average speed of from 8 to 10 miles an hour with one charge; of course longer distances may be covered if desired; the cost of the charge is said to be about 1s.



Thus a run of 30 miles may be made every day in the week for this small sum; the horse to perform a like task has yet to be discovered.

The plate of a "Lamina" cell is of the Planté type, and is composed of sheets of perforated and corrugated lead. The sheets are so arranged that the corrugations run alternately vertically and horizontally. Thus great surface is obtained, and complete circulation of the acid. These sheets are contained in an envelope of perforated and corrugated lead, riveted right through and burned.

The plate is said to have great mechanical strength. Buckling, it is claimed, is impossible. During formation the envelope is protected. Thus it retains its strength and supports the active material.

Extremely high rates of discharge are said to be possible, without doing the slightest damage to the plates. To give an example, one of the car cells, containing seven plates, and weighing 27 lbs., was, we are informed, lately discharged at 190 amperes for 10 minutes, and also at 250 amperes for 2 minutes, and after this a discharge at the normal rate, viz., 20 amperes was taken and full normal capacity obtained.

CORRESPONDENCE.

Electrolytic Alkali at the Hotel Cecil.

I have read with interest the description of the Rhodin electrolytic cell, which appeared in your issue of last week. To-day I notice the issue of the prospectus of a company which proposes to pay £90,000 (£60,000 in cash and £30,000 in shares) to Mr. Harvey, the vendor of the Rhodin patent rights. The absence of any details as to where this cell may be seen at work upon a scale of operations greater than those obtaining in mere laboratory experiments, leads me to conclude that the Rhodin cell has not yet arrived at this intermediate stage of its history. This view is confirmed by the report of Dr. John Hopkinson, in which he refers to the results obtained by the use of "the small apparatus."

The number of cells and apparatus for the electrolysis of salt solutions that have been patented during the past eight years may be counted by dozens. Every one of these would have made an equally interesting exhibit if shown as a model at the Hotel Cecil; and if accompanied by the refreshment for the inner man for which this hotel is famous, the exhibition would have enabled the inventor, his friends, and the representatives of a select group of London technical and daily papers to spend an equally agreeable—and, from a scientific point of view, equally profitless—half hour together.

A room of the Hotel Cecil is no place in which to inspect and test an electrolytic cell for the production upon a commercial scale of caustic soda and chlorine. The idea is absurd.

Not one of the four electrolytic alkali processes at present working was introduced to the public in such a manner. Experimental trials, conducted upon a scale in some degree approximating to those found in actual manufacture, were made, and the experience gained in trials extending over weeks, months, and, in one case, years, was obtained, before any attempt was made to float the process upon an industrial scale, or to bring it before the investing public.

Those who have any knowledge of the construction and operation of chemical plant, know well that plant and apparatus for the conduct of operations at a boiling temperature is always more difficult to construct and to maintain in working order than plant for which no external heating is used. The conduct of the electrolysis at 90° – 100° C. is stated to reduce the required E.M.F. to 3·3 volts per cell. Whether, on a commercial scale of operations, it will pay to heat and maintain a large plant at 90° C., in order to reduce the resistance of the cells, is a question that the Commercial Development Corporation, Limited, has yet to answer. For the benefit of those who are unacquainted with the details of the two most promising electrolytic alkali processes yet in operation—the Castner-Kellner and the Hargreaves-Bird—I

may state that the former works with an E.M.F. of 4 volts and the latter with one of 3·4 volts, when producing carbonated alkali. The superiority of the Rhodin cell, which is stated to work with 3·3 volts at 90° Centigrade, is therefore not very striking.

In conclusion, I may, perhaps, add that I am not financially interested in either of the above companies, or in any of the existing electrolytic alkali companies in this or other countries.

In the case of the company which is now being floated, I regret that the circumstances have compelled me to take up an antagonistic attitude; but as one who has studied and written upon electro-chemical industries for a considerable period, it has appeared to me only right to utter a warning against the investment of money in an apparatus which in my opinion, and also in that of many others, has not been sufficiently tested.

John B. C. Kershaw, F.I.C.

Streatham Hill, S.W.,
November 5th, 1897.

The Lighting of the Side Streets of the City.

Your report of an answer which I made to a question asked me at a meeting of the Commissioners last Tuesday is incorrect. My statement was to the following effect:—

That the Streets Committee had been able, as a result of careful experiments, to form an opinion of the relative useful illuminating values of various systems of lighting the side streets by electricity, but that the factor wanting to a final choice of system was that of price. The price depended necessarily upon the existing public lighting agreements, about the meaning of which there was a difference of opinion, and the adjustment of a complicated situation with a realisation of the full benefit of the provisions of the agreements was causing the delay.

A. W. Voysey,
Electrical Engineer to the Commissioners of Sewers.

The Glasgow Telephone Inquiry.

In your report in to-day's issue of the telephone inquiry at Glasgow, Mr. J. S. Forbes is reported as saying, "Mr. Newland, who was associated with Mr. Bennett," &c.

I should be obliged if you will kindly make a correction to the effect that I have never been associated with Mr. Bennett, and that the estimate referred to, which I prepared for the London County Council in 1895 was altogether independent of that prepared by Mr. Bennett.

Jno. L. Newland.

Electric Heating and Welding.

Could any reader inform me where electrical heating and welding plants can be seen, or where they are in every day operation, and on what systems?

R.

[No doubt the Electric Welding Company, of 21, Hindon Street, Pimlico, would be pleased to show welding plants in operation.]

Leeds and Bradford Light Railway.

In your issue of the 5th inst. you give an extract from the *Yorkshire Post* with reference to the above scheme, wherein it is stated that Dr. Hopkinson and Mr. F. Beanland are the engineers.

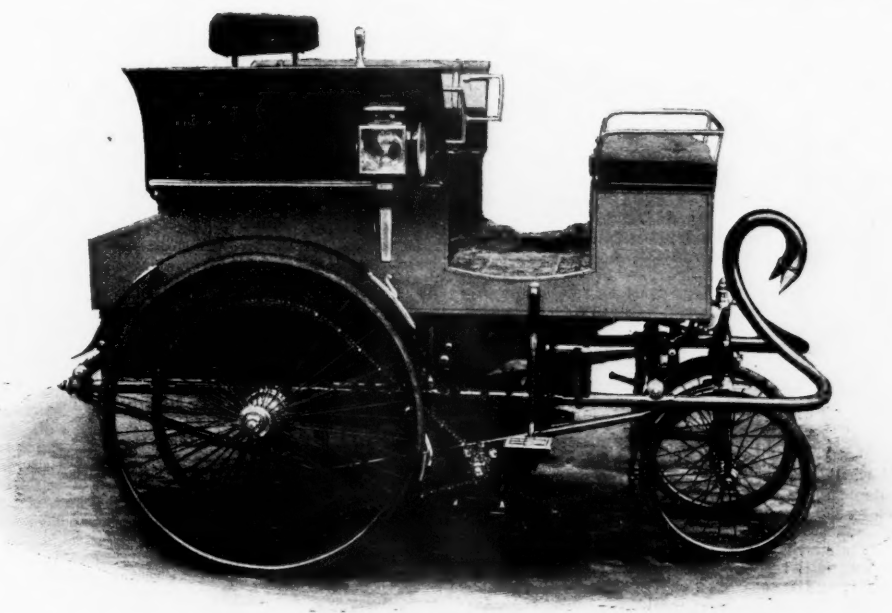
This is an error, as *we* are acting in that capacity. We should, therefore, be obliged if you will kindly make this correction in your next publication.

George Hopkins & Sons.

Westminster.

Dust Destructors.

When writing my last letter, I did so in the hope that by bringing forward facts which seemed to me were being studiously kept in the background, I should be doing a service to those interested in dust destructors, who, not having learnt everything about them by practical experience, have to rely solely on what they are told and read, to guide them in the matter. I have watched the erection and development of several of the municipal electrical undertakings in different parts of the country, and after careful observation, I cannot help but think that it is a great mistake that the efficiency of an electric light supply should depend upon the successful working of a dust destructor, and the steam generating qualities of town refuse. In reference to Shoreditch, we must admit that up to a certain point everything appeared a great success; then, however, before the evenings had drawn in to any great extent, we hear that it is found necessary to burn 30 tons of coal a month. I do not think, as some do, that this points to the failure of the destructors, considering the quality of the Shoreditch dust. I think it more probable that the dust collected is not sufficient to keep the destructor working. If this is the case, where on earth are we to find a place in a more favourable position than Shoreditch in this respect, and if after the plant is erected, it is found necessary



Elieson Electric Motor Car.

to burn coal, owing to an insufficient supply of refuse, what justifies the expenditure of large sums of money on the erection of dust destructors? I am not one to say anything against a dust destructor for no other reason than that it is a dust destructor. I believe that one will form *part* of every municipal lighting plant in the future. I think, however, that a new venture should be worked under the most reliable known conditions. When the undertaking has proved an assured success, there is then plenty of time for the erection of a dust destructor which would no doubt raise sufficient steam for the day load and for charging accumulators; but to depend entirely for a reliable and efficient supply on dust destructors, the successful working of which must at all times depend upon the quality and quantity of dust obtainable, will, I feel convinced, end in failures which will bring the light into bad repute, and tend to retard instead of advance the electric lighting industry.

J. Beresford Bolton.

THE ENGINEERS' STRIKE.

The past week has seen the publication by the Employers' Federation of a statement giving a number of typical instances of Trades Union interference with output, overtime, machine working and shop management. One case is that of a firm who were compelled by the A.S.E. to hand over two copying lathes to two turners, and each lathe was rated at 35s. per week = 70s. for the two. Since the strike, a labourer has been advanced and put in charge of both machines, from which he, singly, is getting more work than the two A.S.E. men did together. The labourer receives 24s. per week, which was a large increase on his former wage. Result, a saving of 46s. a week, and a larger output.

Now, is it not a disgrace to the A.S.E. that a labourer can do more work than two skilled men, and what are we to say to the tyranny which would keep this labourer working at 20s. where he might earn 24s.? What sort of thing is a copying lathe that it must be worked by skilled men? In another case a London firm had an apprentice working between two Union men, all on similar machine tools. The apprentice was "interviewed" by these two men "because he finished three heads (part of a stamp mill) in his day as against their two each." The lad consulted his father as to the choice he should make between cheating his employers out of one third of his work and a broken head. The father having reported the affair to the principal, the lad was removed from his delicate situation and put on other work, and the two unionists were left to do their *minimum* of work.

Here two skilled men deliberately do less work than an apprentice lad, who probably could not have idled away a day in their manner without great irksomeness.

Firms are reporting largely increased outputs since the strike, yet it must be perfectly obvious that a fresh lot of men could not have been taken on to do more work, unless the old hands had systematically shirked their duty. As regards interference, the case is cited of a Salford works, where the A.S.E. wanted to rate a lathe at 38s. a week, which had previously been paid to a discharged turner, although a new turner had applied for the job at 36s.; another case is that of a Blackburn firm, who had a large slot-drilling machine and a small planing machine side by side. They were easily worked by one man, who was brought up by the firm from a labourer by gradual advances until he was receiving 24s. a week. There was no difficulty with him at all, but he fell ill some weeks ago, and the firm endeavoured to get a man to take his place until he was better. The A.S.E. men demanded 30s. for the job, and intimated that, if the machines were given to anyone for less, the A.S.E. men would all hand in their notices.

Numerous other instances are cited of the mischief-making tactics of the A.S.E. which are denied to exist by Mr. Barnes. So it is that the employers have brought forward a few specific instances. We believe the Board of Trade are still endeavouring to secure a settlement; but the A.S.E., at the time of writing, though loudly crying for a conference, and abusing the employers for not running to it, have refused to withdraw the demand on which they first struck. They began the fight, but want the attacked party to be first to lay down its weapons, and we think, much as we deplore the stoppage of trade, that if the employers mean to be masters in their own shops they had better continue the struggle rather than abate one jot of their resistance to interference.

We observe from a leader in the *American Machinist* that this American trade journal is disposed to lay the blame of the contest upon the employers. Naturally the Americans wish the men to win; they wish to see English workmen curtailing output, and they wish to see English employers debarred from the use of labour-saving tools, though they are very anxious to push the sale of American tools in England, and equally anxious that these tools should not be allowed to perform more work than old tools. The *American Machinist* clearly understands the question, and is equally anxious that the strike shall continue to the advantage of America, and takes up, therefore, a tone that it is the English employers who are to blame, the moral of which is that they hope to see the present tactics of the A.S.E. successful, and are not grateful to Burns, who unwittingly and in the fulsomeness of his ignorance of the trade generally, recommended American methods to be followed whilst hounding on the men, his deluded followers, to fight against these very methods. It is unfortunate that the public are not in possession of the true facts of the dispute. Because so many of the A.S.E. are a grimy and unkempt set of men, the public are apt to look on them as being a badly-paid class. Nothing can be more erroneous. The body of mechanics are nearly as well paid as any class of men in the country. Few men of the wage-earning class get more. Possibly the piece-workers in the textile trades are better paid, but the mechanics refuse pay at piece rates, and receive the highest day wages of any class for the amount of work done. That they do not receive more is their own fault, for their persistent efforts to reduce capital to a minimum have recoiled on themselves to a considerable extent, but never to the extent of this last recoil—the Employers' Federation; though if the men are *thoroughly* beaten, we venture to say their wages in 10 years' time will be higher than they were when they struck. It will take 10 years to get over this strike, and to reorganise English trade to the point where foreign competition can be laughed at, and even then we doubt if it will be safe to spare time to laugh.

The A.S.E. possess a good measure of effrontery. They are attempting to pose as injured and crushed mortals, just as though they had been driven to desperation by a hard and cruel taskmaster, in place of having struck work at a time when they were in receipt of big wages and plenty of overtime. In pursuit of this paupers' policy, they appeal to the Church to help in the shape of the Archbishop of Canterbury. Obviously, they expect the Church to take sides in a quarrel by helping the men who want to be kept in idleness. But the Archbishop won't take sides, and no doubt the Church will be roundly abused for pandering to the rich. What rubbish the A.S.E. can deliver itself of is shown in their Mr. Brown's prayer that the Almighty will open the Archbishop's eyes, and his purse. Note the purse! It is this that Master Brown hankers after. Perhaps he is getting a little anxious about his pay?

As regards the question of interference, the A.S.E. would point to its rules, which we believe do not provide for interference. But the interference is practised all the same. The practice of the A.S.E. is not confined to rules, but is an understood thing, just as in Broadhead's days it was "understood" that a man who did not obey orders was about to meet with an accident, and by a strange coincidence he usually did.

The *Times* special correspondent looks to good as an outcome of the struggle. One good result will be the separation of strike funds from benefit funds. This certainly ought to be done, for if made illegal, the future Barnes might find himself in the dock for misappropriating funds which the present Barnes uses gaily for strike purposes. The *Times* also believes that the near future will see machine tools worked in the most economical and productive manner, and that when this is done Great Britain will have a chance of getting back a lot of trade which has been fooled away, and would have continued to be fooled away if this strike and lockout had not come to stop it. Clearly the *Times* correspondent looks on the storm as having cleared the air. If he is right, then everyone ought to be thankful the strike has come, and none more so than the men themselves, who have been fighting for a continuance of all that is included in the term *interference*, and employés all know what it does imply.

As a fact, the A S.E. has been for years sailing under false colours. Professing to be a benefit society, it has drawn men into its embrace by appealing to their care and thrift, and having got them there, it has used their provident fund to foment strikes. It has levelled down the best men, and levelled up the drones, all with the object of piling up a war chest, and it has had its war; the men have found it a delusion, and must surely make a change in the future. All this mischief has arisen because working men, so called, have arrogated to themselves the title of working men, as though no one but they ever did work. Members of Parliament have truckled to them, and there has been a lot of rubbish about sons of toil, and so when votes were to be snatched, the men who have been so fooled by agitators, have been fooled all round. What this country requires are M.Ps. with honesty to speak the truth and drop class distinctions, and who will not sacrifice the country's interest to any howling unwashed mob of voters, led by screaming demagogues who can talk.

There ought to be some easy system of life insurance or old age pension which men of small business knowledge can safely join without being done out of their premiums should they fail at any time to pay up. The A.S.E. have traded upon the lack of this, and have induced men to join them under the illusion that they were laying up for old age. How illusive has been their belief the present strike, which has, we believe, depleted the whole of the provident fund of the A.S.E., shows only too well. The men have joined the A.S.E. because they thought the affair was being managed by their own fellows, and they had no voice in the management. Hence the disastrous results.

At the time of going to press brighter prospects of a settlement were in view, Mr. Ritchie's amended draft being apparently accepted by both sides on the basis of no interference and a withdrawal of the 48 hours' demand.

BUSINESS NOTICES, &c.

Auction Sale.—On Wednesday, December 1st, Messrs. Percy Huddleston & Co. will sell by auction the leasehold premises known as the Copper-Depositing Works, West Ferry Road, Millwall, E., including the fixed plant and machinery. See our "Official Notices."

Electrical Wares Exported.

Week Ending Nov. 9th, 1896	£	s.
Bangkok	307	0
Boca. Teleg. mat. ...	209	0
Bombay	390	0
„ Teleg. mat ...	19	0
Buenos Ayres	971	0
Calcutta	142	0
Cape Town	448	0
Colombo	41	0
Durban	1,291	0
East London	1,121	0
Flushing	88	0
Fremantle	121	0
Hiogo	42	0
Hong Kong	34	0
Jamaica. Telep. mat....	29	0
La Plata	246	0
Malta	70	0
Shanghai	375	0
Singapore	60	0
„ Teleg. mat.	12	0
Sydney	230	0
Wellington	193	0
„ Telep. mat....	493	0
Yokohama	87	0
Total	£7,019	0

Week Ending Nov. 9th, 1897.	£	s.
Adelaide	24	0
„ Teleg. mat....	20	0
Amsterdam	120	0
Antwerp	81	0
Auckland	630	0
Bangkok	44	0
Bombay	238	0
Buenos Ayres	115	0
„ Teleg. mat.	13	0
Calcutta	328	0
Cape Town	248	0
Colombo	20	0
Copenhagen	29	0
Demerara	15	0
Durban	371	0
Gothenburg	60	0
Hamburg	70	0
Hiogo	57	0
Launceston	19	0
Lyttleton	24	0
Madeira	140	0
Madras	12	0
Marseilles	31	0
Melbourne. Teleg. cable.	601	0
Montreal	93	0
Naples	450	0
Philadelphia	183	0
Port Elizabeth	826	0
„ Teleg. mat.	180	0
Shanghai ..	155	0
Singapore	82	0
„ Teleg. mat. ...	32	0
Stockholm	1,050	0
„ Teleg. mat.	612	0
Sydney	1,105	0
Wellington	726	0
„ Teleg. mat. ...	2,470	0
Total	£11,274	0

Foreign Goods Transhipped.

	£	s.
Sydney. Telep. mat. ...	20	0
Trinidad	15	0
Total ...	£35	0

Agencies.—Messrs. Ward & Goldstone, of Manchester, wish us to state that Messrs. A. & W. Hopkins are their sole agents for London for their electric light flexibles, &c., and that they keep a stock on hand.

Messrs. D. H. Bonnella & Son, of 58 and 60, Mortimer Street, Cavendish Square, W., have been appointed sole London agents for Messrs. W. B. Haigh & Co., Limited, of Plane Street, Oldham, for their dynamos, motors, switchboards, instruments, &c.

Bankruptcy Proceedings.—The application for an order of discharge from the bankruptcy proceedings of Messrs. Paterson & Cooper, electrical engineers, of the European Works, Pownall Road, Dalston; Princes Chambers, Victoria Street, Westminster; and 137, Regent Street, Glasgow, was before Mr. Registrar Brougham, sitting at the London Bankruptcy Court on the 5th inst. The firm failed in August, 1896, with a total indebtedness of £19,514, and assets valued as sufficient to pay all claims and leave a surplus of £7,201. It was stated that further time was required for the realisation of the assets, and as the result of such realisation would affect the judgment of the Court, an adjournment of the hearing was desired. His Honour adjourned the hearing until January 28th next.

The failure has been announced at the London Bankruptcy Court of S. Bousfield Tatham, electrical engineer, 26, Thurloe Place, South Kensington. The receiving order was made on Thursday last week upon the petition of W. T. Henley's Telegraph Works Company, Limited, the act of bankruptcy alleged being a recent seizure and sale of the debtor's goods under an execution. Messrs. Linklater & Co. attended on behalf of the petitioning creditors. The amount of the liabilities did not transpire.

Commercial Development Corporation v. Castner-Kellner Alkali Company, Limited.—In the Chancery Division on Saturday last, Mr. Justice Byrne had before him an *ex parte* application by the plaintiffs in the action of the Commercial Development Corporation, Limited, *v.* the Castner-Kellner Alkali Company, Limited, for an injunction restraining the defendants from publishing in the Press certain statements to the effect that plaintiffs' patent—Rhodin's—was an infringement of the Castner-Kellner Company's patent. Plaintiffs alleged that the circular was published for the purpose of preventing people from subscribing to their company. It was stated that the prospectus of the plaintiff company was issued last Thursday, and advertised on that and the two following days in the newspapers. The circular of the defendant company represented that the process which the plaintiff company was formed to work would be an infringement of the Castner-Kellner patents, and it threatened that actions would be brought against those who worked the invention. This had been published in the *Times* on Friday, and had been sent to other newspapers. The injunction was asked for immediately, as Monday was the last day for applying for shares in the plaintiff company, and Tuesday the day for allotment. In support of the application it was said that an injunction over Monday would not hurt the defendants; but unless they were restrained, they might succeed in wrecking the plaintiff company. His Lordship, however, refused to grant an injunction on an *ex parte* application. The plaintiffs then went to the Court of Appeal, but the Master of the Rolls and Lords Justices Chitty and Vaughan Williams also refused to grant an injunction *ex parte*.

Electrical Engineering in South Africa.—The most important electrical undertaking to the fore at the moment—that of the large extension of the electric installation at Johannesburg—has now been advanced an important stage by the signing of the contract with Messrs. Siemens & Halske, of Berlin. The new scheme aims, says the last issue of the *British and South African Export Gazette*, at the extension of the electric mains throughout the various districts of Johannesburg within the jurisdiction of the Sanitary Board, thus enabling the supply of current in the future to be made to houses in various parts of the suburbs hitherto debarred from the luxury. With respect to the Rand electric tram concession, the approval of which was recently negatived by the Raad, fresh efforts made to induce that body to reconsider its decision have failed, the motion to this effect being thrown out by a majority of nine. It is, therefore, now generally considered that this scheme should be regarded as dead, so far as this private company is concerned, the tramway company now being solely in possession of the field as regards electric traction. The contract for the electric lighting of Krugersdorp has also been signed. For the projected electric light installation at Bloemfontein seven tenders have been received, but up to the present no decision upon them has been announced.

Electric Lighting of Asylums and Mills.—Messrs. G. H. Woods & Co., Blackburn, have secured the contract for the whole of the electrical installation for the Lancashire County Asylum at Whittingham, which was recently advertised in our columns. The lighting is for 747 incandescent lamps, supplied by two 35-unit dynamos direct coupled to two 50-H.P. engines. The dynamos are by Messrs. Siemens, and the engines by Messrs. Browett Lindley. In addition to the lighting, they are installing a complete set of intercommunication telephones, fire alarms and electrical time checking arrangement. Messrs. Woods are also now putting down a plant for the electric light for Messrs. Eccles, Limited, in their cotton mill at Lower Darwen, and are just completing the lighting of St. Silas Church, Blackburn, a new building, from the Corporation supply.

Electrical Notes from South Africa.—The November issue of the *British and South African Export Gazette* contains the following news:—The Durban Town Council have decided to lay down their projected tramline so that it may be available for electricity at any future time.—The contract for a large extension of the electrical mains of Johannesburg has been granted by the Johannesburg Sanitary Board to Messrs. Siemens & Halske, Limited, Berlin.—Tenders have been accepted for lighting Krugersdorp with electricity.—Further additions to their electrical plant is contemplated by the directors of Moodie's Gold and Exploration Company, Barberton.—The directors of the Rand Central Electric Works are contemplating increasing their plant from 2,100 to 3,000 H.P. An Ernest Scott & Mountain "Admiralty" type dynamo of 110 volts has been supplied, through Messrs. Parker, Wood & Co., to the Clydesdale Colliery (Transvaal).—An order will shortly be given out for an electric lighting plant for the Tebeque gold mine, Selukwe district, Rhodesia.—Two large generators, of 250 H.P. each, have been supplied to the Violet gold mine by Messrs. Crompton & Co., Limited, Chelmsford.—A complete electric lighting plant has been shipped to Delagoa Bay by the Royal Electric Light Company, Montreal, Canada.—The Cape Town Council are about to import a number of Thomson-Houston electric light meters at a cost of £2,000.—Messrs. Davey, Paxman & Co., Colchester, have received an order from the Natal Government Railways, through Mr. J. W. Logan, their Johannesburg representative, for two direct-coupling dynamos.

Fire.—Last Saturday there was a fire in the premises known as the saw mills, carpenter's workshops, and stores (three floors) at the works of Messrs. Siemens Bros., at Woolwich. The private fire brigade and the Metropolitan Brigade had several hours' tough work to get the fire under.

Hinde v. Prince of Wales, Lord Suffield and others.—In the Lord Mayor's Court, last week, before the Deputy Judge, this case was mentioned. It was an action brought to recover £205,000. The plaintiff, who has been in litigation for the last 25 years in connection with Mr. Allen's claims against the telegraph company and others, commenced an action against His Royal Highness, claiming that the late Under-Sheriff Croll, liquidator of the United Kingdom Electric Telegraph Company, Limited, had paid to his Royal Highness £60,000 which belonged to the late Mr. Allen, of whom plaintiff was assignee. He further claimed from Lord Suffield the sum of £150,000 for suborning Under-Sheriff Croll to commit perjury before the late Lord Bramwell in a trial in the year 1875. Sir George Lewis applied, on behalf of the Prince of Wales and Lord Suffield, to set aside the proceedings upon the ground that no cause of action was disclosed, and that the proceedings were frivolous and vexatious, and an abuse of the powers of the Court. The learned Judge said that it was upon rare occasions that the Court interposed its authority to stay actions, and he certainly would not do so except clear proof was brought before him to justify such a decision. This was a case in which it was clearly proved that there was no cause of action, and instituting such an action was an abuse of the process of the Court. He did not hesitate to dismiss the action.

Holophane, Limited, v. Berend & Co.—In the Chancery Division, on Thursday last week, before Mr. Justice Stirling (taking motions for Mr. Justice Kekewich) Mr. Warrington, Q.C., mentioned the matter of Holophane, Limited, *v.* Berend & Co He said it was a motion for an interim injunction to restrain the defendants from infringing a patent, but a further affidavit had been put in which it would be necessary to consider, and, therefore, he asked that the motion should stand over for a fortnight, when it would come on again before Mr. Justice Kekewich. Mr. H. Terrell, for the defendants, did not oppose this course, and accordingly his Lordship directed that the motion should stand over.

Hurst Enclosed Hydrometer.—The Electrical Power Storage Company are introducing to the market this new hydrometer, which is said to be specially suitable for cells in ebonite boxes, lead boxes, or teak cells, or cells in inaccessible positions. It is also useful for measuring the density of the electrolyte in various portions of the cell. The instrument consists of an ordinary bulb pattern hydrometer, enclosed in a glass tube, attached to which at one end is an India-rubber ball, by compressing which, while the India-rubber tube attached to the other end is held under the electrolyte, the air is forced out, and when the ball is released the electrolyte enters the tube, and floating the hydrometer enables the specific gravity to be read off. By again pressing the ball the electrolyte is returned to the cell, the tube being removed from under the liquid before the ball is again allowed to expand.

King's College Engineering Society.—At a general meeting held on November 5th, Mr. A. W. Minnitt read a paper on the "Manufacture of Steel." The author, after briefly describing the older methods used for the production of steel, dwelt at some length upon the cementation and crucible processes. The Siemens open hearth, and the Bessemer processes, were next dealt with. The effects upon the finished product of the various impurities in cast-iron, and the desirability of retaining or getting rid of them, were pointed out. In conclusion, the author referred to the great use of steel made nowadays for purposes in which iron was formerly employed.

McLauchlan v. Manchester Edison & Swan Company.—At the Salford Court of Record on Friday last, before Mr. Shee, William McLauchlan, of 14, Irwell Street, Broughton, Manchester, claimed £37 10s. from the Manchester Edison & Swan Company, Limited, of Victoria Street, Manchester, as commission on a contract for the electric lighting of Prudential Buildings, Manchester, being 5 per cent. on the amount of the contract, viz., £750. Mr. Rhodes, who appeared for the defendants, said that prior to 1896 the plaintiff received commissions from the company on all work he introduced to them. In December last there was a voluntary winding up of the company, and on the 14th of that month plaintiff was paid £30 in full settlement of all claims against the company, and the agreement was terminated. In January last the contract upon which the plaintiff was now basing his claim was obtained. The plaintiff, on being cross-examined, admitted that he was not to have any commission unless there was a special agreement to that effect, and eventually the jury returned a verdict for the defendant company. Judgment was given accordingly with costs.

New Mica Company.—The Norwegian Mica Company has commenced business at Christiania. The company is working mines of mica in Norway. The board of directors are the Professor of Mineralogy at the University of Christiania, Julian H. L. Fogt, and Mr. Henry E. Mohn, civil engineer, Christiania, the latter as president.

Nicholson & Tyler v. Lawrence.—In the Official Referees' Courts of the Chancery Division, on Monday, the further hearing was resumed of the action in which Messrs. Nicholson and Tyler, electrical engineers and contractors, sued Mr. Joseph Lawrence, of Oaklands Kenely, Surrey, chairman of the Linotype Company, to recover the sum of £206 5s. 6d. for goods supplied and work done in connection with an installation of the electric light at defendant's private residence. The defence was, that plaintiffs had failed to light the house, or to supply plant and machinery in accordance with the terms of the contract, whereby Mr. Lawrence suffered loss and incurred expense in refitting, altering, and putting in new materials, for which he counter-claimed £334 15s. 3d.—The examination of witnesses in support of plaintiffs' case was concluded on Monday, after which Mr. Noad opened the case for the defence. Counsel said the aspect of the case from the point of view of the defendant was very clear and simple. Mr. Lawrence, a man of business, thought he would have his house lighted by electricity; he had it in his City office, where some electrical fittings had been put in, and he asked a person who had some knowledge with regard to these things—Mr. Place, the engineer of the company—to recommend some one to do the work for him at Oaklands Kenely. Mr. Place recommended the people then putting in the light at the offices. In this Mr. Place acted purely and simply as a friend of plaintiff's. Subsequently, Mr. Place wrote a friendly letter to plaintiffs, asking them to confer with his chief—which indicated that Place was acting in a private capacity and not as professional adviser to Mr. Lawrence. Counsel contended with respect to the contract that, on plaintiff's own evidence, the house was not lighted. Plaintiffs were employed as skilled servants, and defendant relied upon their skill. It was not until they came into Court that the defence heard of any suggestion that Mr. Place had been standing in the position of their skilled adviser. As to the objection that defendant had been supplied at his own request with cheap machinery capable of running high efficiency lamps for a certain period, and that he had overrun the plant, Mr. Noad said the plaintiffs had put in lamps of an untried kind, without giving any notice of the peculiarities of these lamps. If any trouble arose, it was in consequence of plaintiffs supplying lamps of that kind entirely unfit for the use to which they were put.—Defendant and other witnesses were examined, and ultimately the further hearing was adjourned until Friday.

Taylor v. Sax.—This case came on for hearing before Mr. Justice Mathew on Friday last. It was an action brought to recover damages for breach of a commission agreement. The defendant had paid £100 into Court, but he was not represented by counsel. According to the statement of Mr. Pickford, Q.C., who appeared for the plaintiff, it seemed that in 1895 the Lambeth Vestry obtained an electric lighting provisional order. Several people were anxious to get a transference of the order, and amongst others the defendant, Mr. Charles William Sax, who was an electrical engineer. It was a question of Mr. Sax or the County of London and Brush Electric Lighting Company getting it. Mr. Sax employed Mr. Gomer, a gentleman who had some knowledge of various members of the Vestry, and some influence, to assist him in obtaining the transfer of the provisional order, and in the formation of a company to work it when obtained. On January 23rd, 1896, the defendant wrote a letter to Mr. Gomer, in which he said:—"In the event of my getting the transfer of the Lambeth Electric Lighting Order, and floating some company successfully, I undertake to pay you £500 in shares in consideration of your doing your best to assist me." The only question was whether the condition, "in the event of my getting the transfer of the Lambeth Electric Lighting Order," was satisfied by the transfer to the company he had formed, and not to Mr. Sax himself. The Vestry decided to transfer the order to Mr. Sax, but the Board of Trade declined to allow it to go to any individual; therefore, instead of being transferred to Mr. Sax, and from him to the company, it was transferred direct to Mr. Sax. The commission note was subsequently assigned by Mr. Gomer to the present plaintiff for valuable consideration. The transfer to the defendant was obtained of the electric lighting provisional order, and, assisted by Mr. Gomer, he was successful in promoting a company called the South London Electrical Supply Company. The shares of the company were £5, with £2 paid, and they stood at par value. His Lordship gave judgment for the plaintiff for £400, in addition to the £100 paid into Court, with costs.

Telephones for Guy's Hospital.—Telephones are about to be fitted in the various wards and buildings in Guy's Hospital. The system adopted is that known as the "Inter-commuication," and the work is being carried out by the Private Wire and Telephone Installation Company.

The Institution of Junior Engineers.—The opening meeting of the seventeenth session of this Institution was held at the Westminster Palace Hotel on November 5th, the chair being taken at the commencement of the proceedings by the retiring president, Sir A. R. Binnie. After the usual preliminary business, including the announcement of the election since the last meeting of 22 new members, the Institution Premium was presented to Mr. W. R. Beckton, for his paper on "The Protection of Buildings, &c., from Fire." On the proposal of Mr. H. B. Vorley, chairman, seconded by Mr. W. J. Hunter, member of Council, for his services as president, the thanks of the Institution were cordially passed to Sir A. R. Binnie, who, having replied, then introduced to the chair the new president, Mr. John A. F. Aspinall, of Horwich. In the address which he proceeded to deliver, the subject of "Some Aspects of Railway Work" was dealt with. Amongst other matters touched upon were included the question of gauge on the African railways, and the comparative cost per 100 ton miles of locomotive power for electric and steam traction, the Liverpool Overhead Railway being taken as an example of the former, the cost in that case being shown as 9·67d.; upon the steam worked railway it was shown to be 4·89d. The proceedings terminated with the announcement of the ensuing meeting on December 10th, when a paper would be read on "Main Engine Auxiliaries in the Mercantile Marine."

The Ward Electrical Car Company.—On Wednesday, in the High Court of Justice, before Mr. Justice Wright, sitting as an additional judge of the Chancery Division for the purpose of hearing petitions for the winding up of companies, a petition was presented by Mr. E. R. Evans, a shareholder, for a compulsory order to wind up the Ward Electrical Car Company, Limited. Counsel for the petitioner stated that the company was formed in 1888; it had never done any business, never owned any omnibuses, nor had any commercial existence. There was no opposition, and his Lordship made the necessary order for the winding up of the company.

Wireless Telegraphy.—At the Röntgen Convention held at St. Martin's Town Hall on the 5th, Mr. H. W. Cox, of Cursitor Street, exhibited an 18-inch coil with which he gave the usual X ray demonstrations. This coil, his own construction throughout, requires only from 12 to 14 volts, and has been used by the maker in connection with some experiments, having for their object a simplified mode of telegraphing without wires.

ELECTRIC LIGHTING NOTES.

Aston.—The District Council has retained Mr. Vaudrey as electrical expert, to advise *re* electric lighting. An inspection of the district has been made, also a selection of streets to be lighted.

Blyth.—An installation of the electric light is being laid down at Blyth Hall. The current is to be supplied by a dynamo driven by an oil engine.

Belfast.—The Belfast Harbour Board, on 2nd inst., approved the General Committee's recommendation that, in accordance with the proposal of the engineer and the electrical engineer, tenders for a portion of the plant in connection with the harbour electric lighting scheme be accepted, provided such tenders were lower than the estimate.

There is a gratifying increase in the demand for current, particularly for motive power purposes, but as the engineering strike has hindered the completion of the extension plant no more customers can be taken on at present.

Buxton.—We understand that a company has given notice of intention to apply for a recision of the provisional order obtained by the Council three years ago, and to promote a new order for itself. A Committee of the Council is considering the matter.

Canterbury.—The Town Council has received the sanction of the Local Government Board for the £23,000 electric lighting loan. Land is to be purchased at Northgate for a site. Tenders are to be invited for the necessary plant, building, and destructor.

Cheltenham.—A Local Government Board inquiry is arranged for this week regarding the Council's application for a loan (£18,385) for electric lighting extensions.

Colne.—The Council has resolved in favour of electric lighting, and the manager of the Gas Department is to submit plan showing a proposed site for an electricity station, also cables running in certain thoroughfares.

Coventry.—The following is the statement of the Electric Light Committee for the quarter ending September 30th:—Electricity supplied during quarter, 1897, 13,155 units; 1896, 8,869 units; for rental, 1897, £340 4s. 9d.; 1896, £228 5s.; number of consumers on September 30th, 1897, 95; 1896, 65; mileage of mains on September 30th, 1897, high tension, 2 miles 337 yards; low tension, 2 miles 816 yards; 1896, high tension, 2 miles 77 yards; low tension, 2 miles 332 yards.

Dorking.—Mr. F. J. Warden-Stevens has completed his report for the Dorking Council on the electric supply scheme for the district.

Dublin.—Mr. Ruddle, the superintendent of the Dublin Corporation Electricity Supply, Central Station, Fleet Street, Dublin, writes as follows regarding our note under this heading last week:—"Referring to a paragraph headed 'Dublin' in your current issue, I am surprised you should reproduce a sensational account of an occurrence without making some inquiry as to the actual facts. So far as I can find, no such accident occurred in connection with our lighting system as is reported, and, in fact, it was an impossible occurrence. It is true that a man went to an hospital and stated he had received a shock, but no symptoms could be discovered at all of anything of the kind, and, in fact, the doctors attributed the shock to another and *more common* cause." Apparently the reports and correspondence in the Dublin newspapers were very much exaggerated.

Dundee.—During the six months ending October, £1,594 5s. 11d. was received as electricity rental, an increase of £210 14s. 8d. over last year. The electricity supplied to the four arc lamps on High Street cost £13 14s.

Fermoy.—In respect to our last week's note under this heading, Mr. F. J. Warden-Stevens writes:—"The situation at Fermoy is as follows:—The terms of an agreement between the Commissioners and a company have been settled. I am the consulting engineer for the latter, and have prepared a scheme and plans for the lighting of the town. The Commissioners decided to call in an engineer to approve of these, and it is no doubt to the appointment of this engineer that the note refers. The matter of his appointment cannot, however, have been postponed, as I was informed by the Clerk that Mr. T. Tomlinson had been appointed. With respect to the last portion of the note:—'The Commissioners did not seem to know their own minds upon the matter, whether to go in for electric lighting or not,' this is inexplicable to me, and I should be pleased to know the source from which it was derived. As the note may cause misapprehensions as to my position in the matter, I shall be pleased if you will make this correction."

Hackney.—The Vestry last week passed a resolution referring to a joint committee to consider the advisability of transferring the electric lighting order, or retaining the same, and report fully on the whole question, and submit schemes.

Halifax.—The parish church has been lighted by electricity, supply being taken from the Corporation mains. Messrs. Dixon & Sons, of Leeds, carried out the installation.

Hampstead.—At the last Vestry meeting it was stated that the new plant for the electricity works would probably be fixed in a fortnight's time.

The question of lighting High Road, Kilburn, has been postponed until the Willesden District Council has obtained its provisional order.

Hereford.—The *London Gazette* for Friday last contains a copy of the application being made by the Corporation for an electric lighting provisional order.

Hornsey.—The District Council has referred the question of electric lighting to a special committee.

Knottingley.—If the Gas Company does not accept the offer of the District Council *re* gas lighting, the Council will take steps to provide electric lighting.

Lewes.—Mr. F. J. Warden-Stevens's report on the electric lighting of the borough has been considered in committee, and the Corporation has decided to act upon it, and is applying for a provisional order this session.

Leyton.—Mr. Bishop, the electrical engineer, has asked to be allowed to lay mains on the Abbott's Park estate without waiting for the sanction of the Local Government Board. The matter was referred to the Electric Lighting Committee with power to act. The engineer has also reported as follows:—"Number of customers on books, 66; increase from last report, 7; units sold during September, 8,611; units generated during September, 12,573; maximum current during September, 270; lamps installed to end of September, 3,839; lamps installed during the month, 131."

Lincoln.—The electrical engineer, Mr. Vesey Brown, explained to the Council the other day three schemes for lighting certain parts of the city electrically. The scheme selected for acceptance includes 27 arc lamps for street lighting.

Llandaff.—The District Council has consented to the application to the Board of Trade for a provisional electric lighting order for the Penarth Electric Lighting Company to supply electricity in Landaff, Llanishen, and Lisvane.

London.—The Strand Board of Works has refused the application of the Charing Cross and Strand Electric Lighting Company for permission to take up parts of Wellington Street for the purpose of laying down pipes, &c.

Long Eaton.—The District Council has decided to hold a special meeting to consider the advisability of introducing the electric light.

Maidstone.—The Maidstone Urban District Council have decided to carry out the Electric Lighting Provisional Order.

Oldbury.—The Council, after conferring with the representatives of the Midland Electric and Power Distribution Corporation, Limited, has decided to go on with its own application for a provisional order.

Provisional Orders.—The *London Gazette* for Tuesday last, contains notices of applications for provisional electric lighting orders for the following towns or districts:—Barnes, Rochdale, Bermondsey, Maidenhead, Friars Place Estate, Acton (application by J. de Lara Cohen).

Shoreditch.—At the last Vestry meeting a report was submitted by the Lighting Committee expressing the opinion that any consumer guaranteeing to use 100,000 units per annum of day load at 2d. and 3d. rate, should have a rebate for current, and for light during daytime to be equal to the same charge. The suggested rebate was ordered to be given. The Lighting Committee further reported that they had carefully considered the engineers' report and estimates for new engines, additional boilers, extension of mains and house connections, and for meters which they deemed advisable to be paid out of borrowed money, and they recommended the Vestry to now authorise an expenditure not exceeding £20,000 for the purpose intimated, and that the sanction to borrow the money be obtained from the London County Council.

Spain.—A central station is being erected at Rubi (Barcelona). Gas engines will be employed to drive the dynamos.

Stonehouse.—Official notice has been given of the intention of the East Stonehouse District Council to apply for a provisional order.

Walton-on-Thames.—The Walton-on-Thames Electric Lighting and Power Company have notified the Board of Trade of their intention to apply for a Provisional Order during the ensuing Session of Parliament.

Waterloo.—The District Council considered the other day the desirability of lighting some of the principal streets by electricity, and tenders are to be obtained for five lights.

West Ham.—Alderman Govier laid the foundation stone of the new pumping and electric lighting station at Abbey Mills on 3rd inst.

Wolverhampton.—On the occasion of the mayoral ball last Monday night, the Drill Hall was illuminated by electricity by the Walsall Electric Lighting Company.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Airdrie and Coatbridge.—The Town Councils of Airdrie and Coatbridge are considering the proposals of the new General Traction Company, Limited, for laying a tramway line between Langloan, Coatbridge, and the east end of Airdrie. Meanwhile the British Electric Traction Company have given notice of their intention to apply to the Light Railway Commissioners for powers to lay a light railway on the same track, and have lodged plans and description for the inspection of the public.

Bournemouth.—The Roads Committee of the Bournemouth Council has decided to have all the three applications from Messrs. Burt & Haviland, the Bournemouth, Boscombe, and Westbourne Omnibus Company, Limited, and the British Electric Traction Company, printed and circulated for the benefit of the Council, and has referred them to a committee of the whole Council. The Dorset County Council when the schemes came before it last week decided to refer them to the Parliamentary Committee with power to act.

Brierley Hill.—The District Council has been considering its resolution insisting upon the British Electric Traction Company taking their electric current from the Council. The Tramways Committee has interviewed representatives of the company, and has been given to understand that such a stipulation might lead to the abandonment of the scheme; but, on the other hand, if the resolution were withdrawn, the company would erect a power house for generating electricity in the Council's district. The Council has accordingly, on the Committee's recommendation, rescinded the resolution.

Brighton.—A topic for conversation and discussion has been supplied by the appearance in print of the official notices relating to an underground railway scheme for this borough. Railway No. 1 is to commence under Queen's Road, at or near its northern end, and terminate under King's Road, opposite the end of Russell Street. Railway No. 2 is to commence by a junction with No. 1 under West Street, and terminate under King's Road, opposite the end of Middle Street. It is proposed to make openings directly on to the beach. The gauge to be adopted for the proposed railways will be the standard gauge of 4 feet 8½ inches, "and the motive power to be employed will be electricity, or such other mechanical power as may be prescribed or authorised by the intended Act." Powers are to be sought "to purchase by compulsion or agreement lands, houses and other property and easements therein for the purpose of the intended Act, and in particular to empower the company to purchase and acquire by compulsion or agreement, and to hold and use for the purposes of a station for generating electric power, with all necessary or convenient buildings, works, engines, dynamos, apparatus and conveniences, &c." The company also seeks power to make agreements with the London, Brighton and South Coast Railway Company for the interchange, delivery, and transmission of traffic. Plans, &c., will, on or before November 30th, be deposited with the Clerk of the Peace for Sussex, and the Town Clerk of Brighton, for public inspection. The solicitor for the Bill is Mr. John Battams, 23, Rood Lane, E.C., and Parliamentary agents are Clierwood & Co., 7, Great George Street, Westminster, S.W.

The British Electric Traction Company have given notice to the Brighton Town Council of their intention to apply for a Provisional Order for powers to construct an electric tramroad from the Central Station of the London, Brighton and South Coast Railway in Queen's Road to the Lower Esplanade. The Town Council have resolved to strenuously oppose the project as being highly objectionable. This, we presume, is the scheme to which we referred last week.

Bristol.—On 4th inst. Major Cardew made an inspection of the Staple Hill and Fishponds sections of the electric tramways on behalf of the Board of Trade. There is now a regular service between Old Market and Staple Hill.

Cork.—Some of the Irish papers are referring to the fact that American made rails are being employed for the Cork electric tramways now being laid down. Several consignments of rails have already been received.

Folkestone.—In respect to the proposal of a company to introduce electric tramways in Folkestone a public meeting has been held, and a committee was appointed to take the necessary steps to oppose the introduction of electric tramways into the town.

Germany.—It has been decided by the Prussian Railway Minister, Herr Von Thielen, next year to substitute electricity for steam on the railway between Berlin and Potsdam, in order to test the adaptability of the electrical locomotive for general railway traffic. The engineers maintain that traffic conducted by electricity will be both cheaper and faster than the present system. The line between Berlin and Potsdam, on account of its many suburban stations, is, says the *Pall Mall Gazette*, one of the busiest in the whole of Germany.

Hartlepool.—The Town Clerk is to write to the Hartlepool Electric Tramway Company, drawing attention to the manner in which the electric cars were worked.

In the County Court, Dr. Gamlen secured £33 damages and costs against the company for personal injuries alleged to have been sustained through the negligence of the company.

Hastings.—An order is to be applied for to enable the construction of light railways for the borough of Hastings. It is proposed to construct one line from the junction of the roads at Silverhill to near the Albert Memorial, and another from Grosvenor Gardens, St. Leonards, to the junction of George Street and East Parade, Hastings.

Isle of Man.—The *Isle of Man Times* for Saturday last publishes the full text of the Act, as passed by the Insular Legislature, authorising the Isle of Man Tramways and Electric Power Company, Limited, to construct a line of tramways from Laxey to Ramsey.

Kinver.—The Parish Council have decided to oppose the application of the British Electric Traction Company, Limited, to construct a light railway to Kinver.

Llandudno.—At a special meeting of the Council in committee on Monday it was resolved by 16 votes to 2 that the Council forthwith apply for a Provisional Order for the construction of tramways within the Council's area.

North Shields.—The Northumberland County Council, last week, received a report from the Bridges and Roads Committee as follows:—The following paragraph was submitted as an addition to the Bridges and Roads Committee's report, and was allowed to be included:—Quite recently the British Electric Traction Company, Limited, have given notice to the Council that they intend to apply to the Light Railway Commissioners for an order authorising light railways in the borough of Tynemouth and in the urban district of Whitley. The proposed light railways are really an extension of the existing tramway system from Saville Street to the New Quay, and from the termination of the present lines to Whitley. The application will be made to the Commissioners this month, and it may be that the inquiry which will be held by the Commissioners will take place before the meeting of the Council in February next. The Committee have not yet had an opportunity of communicating with the local authorities, nor of fully considering the matter, but inasmuch as it is one which will not admit of delay, they propose to do both at an early date.

Paisley.—It is stated that a company is likely to be formed to take over the tramways with the object of substituting electric motor power for the present horse haulage.

TELEGRAPH AND TELEPHONE NOTES.

An All-British Cable to Australia via the Cape of Good Hope.—The following article appeared in Tuesday's *Times* from the pen of "A Correspondent":—As several incorrect and misleading statements on this subject have been recently made public, a few facts relating to the proposition laid before her Majesty's Government may be of interest. The first part of the project is to lay cables from Porthcurnow, in Cornwall, to Gibraltar (1,198 knots), Gibraltar to Sierra Leone (2,379) or Bathurst, thence to Ascension (1,168), on to St. Helena (810), and from there to Cape Town (1,910). This will afford a triplicate route to South Africa largely clear of existing cables, and not likely to be affected by causes producing interruption of the present lines, such as earthquakes, or, in the case of cables on the coast, river floods. All experience shows that duplicate cables, even when separated by such a continent as Africa, do not afford sufficient security against interruption of communication, and the new route referred to will, if laid, be welcomed by all connected with South Africa as diminishing the risk of communication being cut off. The second part of the scheme is to lay a cable from Natal to Mauritius (1,818 knots). This, in conjunction with the present Zanzibar-Seychelles-Mauritius line, will also have the effect of providing an alternative to the following sections, should they at any time be interrupted:—Zanzibar-Mozambique (already duplicated), Mozambique-Delagoa Bay, and Delagoa Bay-Durban. From Mauritius the route may be to Rodriguez Island (406 knots), thence to Cocas or Keeling Island (2,218), and on to Perth, Western Australia. It is proposed that these cables should be laid by the Eastern, the Eastern and South African, and the Eastern Extension, Australasia, and China Telegraph Companies. When completed, this new route from England to Australia will form the very considerable addition of about 13,684 nautical miles to the existing submarine cables, which have been manufactured and laid by British industry and enterprise, and are worked by British clerks. As already stated, the new cables will land only in British possessions, and will form a triplicate route to Australia, removed from the volcanic dangers of the Java Seas; while experience on both sides of Africa shows that interruptions from seismic disturbance there are not frequent. This scheme is put forward in the judgment of the companies concerned as being preferable in every way to the Pacific route to Australia, where a single break in the chain would interrupt communication; while in the proposed scheme, except in the case of the cables from Mauritius to Perth, if any of the sections were broken there would be two alternative lines as far as Zanzibar, and one between that place and Mauritius. Some of the depths in the Pacific are very great, while in the projected line the recorded soundings indicate no greater depth than cables are already lying in. Again, in the Cape route the distances are all practicable without making the cables too expensive, because in a section much above 2,000 miles in length, the amount of copper and gutta-percha insulation used would have to be largely increased to secure a good working speed. In place of the route given above it has been erroneously stated that the projected lines were to go from Mauritius to Ceylon, Singapore and Batavia to Australia; and in one Press reference to the matter it has been stated that such a cable would be liable to prohibitive dangers from seismic interruptions, but it may be pointed out that the existing lines from Madras to Australia have not by any means ruined the proprietor company by the cost of repairs, and that communication between this country and Australia has not been once interrupted since 1890. This pessimistic view of the matter is supported in the case referred to by attributing all the interruptions which have occurred during periods of from 9 to 17 years on the Madras—Penang, Singapore—Batavia, and Java—Port Darwin cables to a single year, and further giving a seismic or volcanic cause to all the breaks or faults which have occurred on those sections; whereas most of the trouble of the early days was due to the Teredo boring-worm and abrasion over rocky ground. Fortunately an effectual remedy appears to have been found in respect to the former danger

by the adoption of a brass taping laid spirally round the gutta-percha insulator, and in regard to the latter, the cable was re-laid on a better bottom. When it is remembered that interruptions may be due to many other causes, from a fish-hook to a whale, it will be seen how greatly the earthquake danger has been exaggerated. Finally, it may be said that the land-line communication between Perth and the south and east of Australia is ample and reliable.

Cable Mark Buoys.—The Eastern Telegraph Company have reported to the Board of Trade, says the *Times*, that one of their telegraph cable mark buoys off the coast of Portugal had been found to be pierced in seven places by bullets, and it is supposed that some person had tried to sink it, under the impression that it was a buoy which had broken adrift. Masters and officers are informed that the telegraph cable mark buoys of this company may be known by the fact that they carry a pole with a circular wicker cage on the top, with a flag in the daytime and a lamp at night, the top of the buoys being painted with alternate black and white, or red and white squares.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (Anglo, 1869)	April 6th, 1893 ...	...
West Indies—		
St. Croix-Trinidad ...	Nov. 30th, 1896 ...	...
Cayenne-Pinheiro (Brazil)	Sept. 29th, 1897 ...	...
Paramaribo-Cayenne ...	Oct. 25th, 1897 ...	...
Santiago-de Cuba-Guantanamo	Oct. 29th, 1897 ...	...
Amazon Company's cable—		
Parintins-Itacatiara ...	May 5th, 1896 ...	...
Obidos-Parintins ...	Dec. 7th, 1896 ...	...
Cable beyond Santarem ...	Oct. 23rd, 1697 ...	...
Hong-Kong-Macao	Sept. 28th, 1897 ...	Nov. 9th, 1897.
Otranto-Vallona	Oct. 11th, 1897 ...	...
Cadiz-Teneriffe	Oct. 26th, 1897 ...	...
Bundaberg-New Caledonia ...	Nov. 4th, 1897 ...	...
San-Thomé-Loanda	Nov. 8th, 1897 ...	...
Landlines.		
Trans-Continental line beyond Masol	March 12th, 1896 ...	...
Carthagena-Barranquilla (Columbia)	July 4th, 1896 ...	...
Communication between Chimois and Beira (South Africa)	Nov. 2nd, 1897 ...	Nov. 8th, 1897.

The Telegraph Wire Export Trade.—The returns just issued for October show that the export trade of this country in telegraph wire and apparatus connected therewith continues very quiet. The total exports during the month, although slightly greater than in September last, only amounted to £47,746, as compared with £162,054 in the same month of last year. During the 10 months ending with October, the exports have reached a total value of £794,621, as against £699,905 in the corresponding period of 1896. Although the increase in the trade over last year is steadily diminishing, the returns are, on the whole, fairly satisfactory; the advance for the 10 months standing at £94,716.

CONTRACTS OPEN AND CLOSED.

OPEN.

Blackpool.—November 22nd. The Corporation wants tenders for various works required in the conversion of the present system of electric traction. There are four sections as follows:—

A. Steel columns, brackets and straining posts.
B. Trolleys, trolley wire and insulators.
C. Controllers, motors and gearing.
D. Mains and section fuses.

Borough electrical and tramway engineer, Mr. Robert C. Quin. See our "Official Notices" October 29th for further particulars.

Blackburn.—The Corporation wants tenders for eight tramcar bodies with trucks, motors, controllers, trolley posts, &c. Engineer, Mr. E. M. Lacey, 10, Delahay Street, S.W. See our "Official Notices" for particulars.

Bradford.—The Guardians want tenders for the wiring of Nurses' Home at the Union Workhouse. Particulars at the Poor Law Offices, 22, Manor Row, on payment of 10s. deposit.

Burnley.—November 17th. The Corporation invites tenders for the supply and delivery of lead-sheathed, armoured, underground cables. Borough Electrical Engineer, Mr. W. R. Wright. See our "Official Notices" October 22nd.

Derby.—November 16th. The Midland Railway Company is inviting tenders for the supply of stores. Items 10, 10*a* and 10*b* are for telegraph instruments, telegraph stay rods, bolts, &c., galvanised, telegraph and signal wire. Particulars from Mr. G. Morrall, Stores Superintendent, Derby.

Hull.—November 25th. The Corporation is inviting tenders for the supply of about 2,800 tons of steel girder tramway rails, fish-plates, sole-plates, tie-rods and bolts. For particulars write to Mr. A. E. White, city engineer, Town Hall.

Queensland (Aus.).—November 15th. The Municipal Council of Ipswich, Queensland, is inviting tenders for the supply and erection of the following electric lighting plant, &c.:—Tubular boilers, pipes, pumps and heaters, alternators and exciters, switchboard, high and low tension mains, junction boxes, transformers, &c. Specifications, and all particulars as to conditions, &c., may be obtained from Messrs. Gordon & Gotch, St. Bride Street, Ludgate Circus, London, E.C., and tenders have to be forwarded to the Town Clerk (Mr. Albion Hayne), Council Chambers, Ipswich, Queensland. See "Official Notices" September 17th.

Roumania.—November 15th. Tenders are being invited by the Municipal Authorities of Ploesti, for the concession for the establishment and working of an electricity generating station in the town during a period of 40 years, for private and public lighting and also for power transmission purposes.

Singapore.—December 31st. The Municipal Commissioners are inviting tenders for the lighting of street lamps for a period of five years. Particulars from Mr. C. C. Lindsay, 167, St. Vincent Street, Glasgow, or the secretary to the Municipal Council.

Spain.—November 21st. Tenders are being invited by the General Direction of the Spanish Posts and Telegraphs in Madrid for the supply of 25,000 porcelain insulators. Tenders to be sent to the Direccion General de Correos y Telegrafos, Madrid.

Warrington.—December 3rd. The Cheshire Lines Committee are inviting tenders for the supply of stores and materials for the year 1898. There are nineteen items, No. 6 being for telegraph materials, instruments, wire, &c. Particulars from Mr. S. Saxton Barton, storekeeper, Cheshire Lines, Warrington.

CLOSED.

France.—The Compagnie Electro-Mecanique, of Paris, has secured a contract for the establishment of a central station at Saint Ambroix (Gard).

FORTHCOMING EVENTS.

1897.

Friday, November 12th, at 5 p.m.—Physical Society of London, at the rooms of the Chemical Society, Burlington House. (1) "On the Isothermals of Ether," by Mr. Rose-Innes. (2) "On the Variation with Temperature of the Electromotive Force of the H-form of Clark Cells," by Mr. F. S. Spiers and Mr. F. Twyman. Council meeting at 4 p.m.

Friday, November 12th, at 12 o'clock noon.—Thirty-fourth ordinary general meeting of the Western and Brazilian Telegraph Company, Limited, at Winchester House, E.C.

Wednesday, November 17th, at John Street, Adelphi.—Society of Arts. Opening address by Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Chairman of the Council. Subject "The Colonies: Their Arts, Manufactures and Commerce."

Wednesday, November 17th.—Liverpool Engineering Society, Royal Institution, Liverpool. Paper by Mr. Sherard Cowper-Coles, A.M.I.C.E., M.I.M.E., on "Electro-zincing."

Wednesday, November 17th.—Latest date for the receipt of tenders for electric lighting cables for the Burnley Corporation.

Wednesday, November 17th, at 7.30 p.m., at 28, Victoria Street, S.W.—Institution of Electrical Engineers. Annual General Meeting of the Students' Section for the election of Committee and Secretary.

Thursday, November 18th, at 8 p.m.—Chemical Society, Burlington House. Papers to be read:—"On the Decomposition of Camphoric Acid by Fusion with Potash or Soda," A. W. Crossley, M.Sc., Ph.D. and W. H. Perkin, jun., F.R.S. "Experiments on the Synthesis of Camphoric Acid," W. H. Bentley, B.Sc. and W. H. Perkin, jun., F.R.S. "The Action of Magnesium on Cupric Sulphate Solution," Frank Clowes, D.Sc. and R. M. Caven, B.Sc. "Properties and Relationships of Di-hydroxy Tartaric Acid," H. J. Horstman Fenton, M.A.

Thursday, November 18th, at 8 o'clock.—City and Guilds Technical College, Finsbury, E.C. The second of a series of six lectures on "Electric Traction," by Philip Dawson, M.I.C.E.

Saturday, November 20th, at 3 p.m.—Institution of Junior Engineers' visit to the Islington Vestry Electricity Works, Eden Grove, Holloway Road.

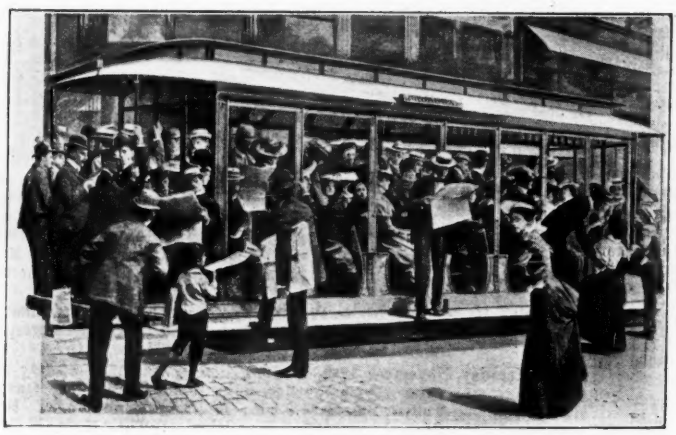
Saturday, November 20th, at Sunderland.—(Council Chamber, Town Hall), Northern District meeting of the Incorporated Association of Municipal and County Engineers. Among the papers to be read is one by Mr. J. F. C. Snell, A.M.I.C.E., on "The Sunderland Electric Generating Station." The Electricity Works will be visited in the afternoon. Dinner at the Grand Hotel at night.

Tuesday, November 23rd.—Royal Victoria Hall, Waterloo Bridge Road, S.E. "The Gas Helium and How It was Discovered," by Prof. Ramsay, F.R.S.

NOTES.

Polyphase Currents.—We announce with much regret that the MS. and translation of Prof. Hospitalier's article on "Polyphase Currents," which should have formed one of the special contributions to this issue of the REVIEW, was lost in transit to this office. It is all the more vexatious as M. Hospitalier expressed his ready willingness to co-operate with us in such amiable and friendly terms that we feel the unfortunate loss keenly, and we are sure our readers will feel equally disappointed at being deprived of a paper, the subject of which the author has made peculiarly his own. We have made enquiries in every possible direction, and if the documents should come back to us we will publish the article in a future number. To M. Hospitalier we tender our most sincere regrets that his kindness to us should have been so unhappily rendered futile.

How They Travel in New York.—"New York City stands at a critical point in its history," so says the *Railway World* in a recent article, and we reproduce a photograph which proves that contention up to the hilt. The picture is a speaking one. It represents a summer cable car on the Broadway line preparing for the journey up town, and the passengers not finding seats have crowded every inch of standing room, even making use of the buffer outside the rear dashboard, on which a precarious foothold is maintained only by strenuous grip on the railings of the car. Talk about the comforts of modern travel! They have them with a vengeance on the Broadway. Only fancy the happy lot of a conductor threading his way among the fares, "All tickets please!" The selfish Englishman is not content with hanging on behind, and so, thanking heaven that in this country there is such a thing as a fine imposed for overcrowding, he prefers the old way to the new.



CABLE CAR ON THE BROADWAY, NEW YORK.

Society of Arts.—Sir Owen Tudor Burne's Presidential Address on 17th inst. will be followed by four meetings on successive Wednesdays before Christmas, at which papers will be read by Prof. James Douglas, on "The Progress of Metallurgy and Metal Mining in America during the last Half Century;" by Prof. Leonard Waldo, D.Sc., on "The American Bicycle: the Theory and Practice of its Making;" by Bennett H. Brough, on "The Stockholm Exhibition of 1897;" by Samuel Rideal, D.Sc., on "The Purification of Sewage by Bacteria." The first course of Cantor lectures will consist of three lectures, to be given on Monday evenings, commencing on the 29th inst., by Dr. Eugene F. A. Obach, F.C.S., on "Gutta-Percha."

Motor Cars and the Lord Mayor's Procession.—We have received copies of correspondence which has passed between the Elieson Lamina Accumulator Company, Limited, and the Lord Mayor and Sheriffs' Committee. The company applied for their motor car to be included in the Lord Mayor's procession, but were on 21st ult. informed that no motor car could be included. On 5th inst. a printed circular was received, giving instructions as to the time and place for the electric car to join the procession, but the following day the company was informed that this had been sent in error, and was intended for some one else.

The Institution of Electrical Engineers.—A comparison of the number of members of all classes in the Institution in 1872 and at the present date is interesting:—

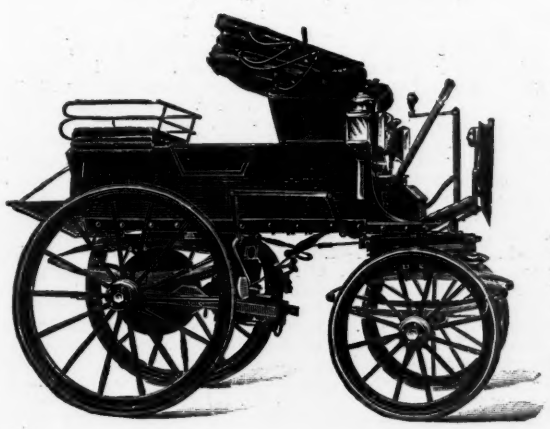
1872.		1897.	
Honorary members ...	0	Honorary members ...	1
Foreign " ...	20	Foreign " ...	176
Members	153	Members	619
Associates	178	Associates	1,729
Students	2	Students	237
	353		2,762

Direct Spanish Telegraph Company.—On Saturday last, in commemoration of the twenty-fifth anniversary of the incorporation of the Direct Spanish Telegraph Company in 1872, the members of the staff assembled at the Trocadero to do honour to an excellent dinner, at which Mr. J. F. Mills, the superintendent, presided. The occasion being also the anniversary of the manager, Charles Gerhardi, Esq., in directing the affairs of the company, the staff were celebrating a double event; the success and progress of the company being due in a great measure to his administration, capacity, and keen foresight. The company was launched upon troublous times. On December 31st, 1872, communication was first established between the Lizard and Bilbao; but owing to the Carlist war, it was interrupted from August 18th, 1873, to May 5th, 1874, when the cable was diverted from Bilbao to Santander, communication not being again restored with Bilbao until April, 1876. The Marseilles-Barcelona cable was laid in 1874. When the cable was first opened the Siemens polarised relay was used, but owing to the prevalence of strong earth currents, resort was made to mirror working. The Allan Brown relay was then adopted, doing away with mirror working. In March, 1881, underground cables were laid between Lizard and Falmouth, to enable direct working thence to Bilbao. On January 1st, 1883, communication was established between London and Bilbao, also between London and Madrid, a distance of about 1,300 miles; this being the longest Morse circuit in practical daily use from London. In May, 1884, a new cable was laid between Bilbao and Kennack in Cornwall, since which date, with one or two exceptions, communication with Spain has been uninterrupted. In July, 1889, the offices in Leadenhall Street were removed to more commodious premises at 74, Gracechurch Street. In January, 1891, owing to great increase of traffic the system was duplexed, and in July of same year a sub-office was opened at Winchester House. In November, 1893, a sub-office was opened at Covent Garden Market, and in January, 1895, Liverpool and Manchester were added to the list of the company's stations. In April, 1896, the electric light was installed at the London offices, with material benefit to the staff. From April 1st, 1893, the insurance and endowment scheme was introduced into the service through the exertions of the manager, and it may be mentioned that the insurance has recently proved a great boon to the wife and child of one of the late clerks at Barcelona. Mr. Gerhardi, the guest of the evening, received the cordial thanks and good wishes of the staff for continued prosperity and ability to direct the ever-increasing success of the company. At this gathering the superintendents of the Atlantic cable companies were present, and congratulatory telegrams were received during the evening from Bilbao, Marseilles, Barcelona, and Falmouth.

Electricity in a Church.—Not only is the new St. George's Church, in Berlin, to be supplied by electricity, but the organ-blowing mechanism is to be actuated by a 2½ H.P. electromotor. A motor of 10 H.P. is also to be laid down for the ringing of the church bells. The electromotors are being supplied by Messrs. Siemens & Halske, of Berlin.

Falcon Works Engineering Society.—The inaugural meeting of the fourth session of this Society, which is formed of the staff and employés of the Brush Electrical Engineering Company, was held at the works at Loughborough, Leicestershire, on Thursday the 4th inst., when Mr. Percy Sellon delivered an address reviewing the history of the Society and of the Falcon Works, and explaining the extensions which the company are carrying out and have in contemplation at the works.

Headland's Motor Carriage.—We illustrate below the electric carriage of Headland's Patent Electric Storage



Battery Company, Limited, which took part in the Lord Mayor's procession on Tuesday last.

River Plate Shock Fatalities.—From the *Review of the River Plate*, October 9th, we cull the two following items:—

On Monday night one of the employés of the River Plate Electric Light and Traction Company was killed in Tucuman whilst arranging one of the arc lamps in the streets, through coming in contact with the high tension mains.

An employé in the electric light station of the River Plate Electric Light and Traction Company, in Rosario, was killed on Thursday night by coming in contact with the high tension mains.

We wonder what precautions are taken by the River Plate Company and their employés for the prevention of such mishaps!

Sax, Slatter & Co.—We have received another communication from Mr. Slatter, which we are unable to deal with this week. We propose to do so in our next issue.

NEW COMPANY REGISTERED.

Electric Reduction Company, Limited (54,724).—Registered November 5th with capital £40,000, in £1 shares, to adopt an agreement with the Anglo-Continental Gold Syndicate, Limited, to work and develop the processes mentioned in the said agreement, and to reduce ores of all kinds, and to carry on the business of electricians, mechanical engineers, suppliers of electricity. The subscribers (with one share each) are:—A. W. Berry, 22, Austin Friars, E.C., secretary; A. Larsen, 22, Austin Friars, E.C., secretary; E. Pears, Hitherfield Road, Streatham, S.W., secretary; E. P. Tennant, 13, Culmore Road, Peckham, S.E., clerk; T. H. Riches, Shenley Road, Camberwell, S E, clerk; A. J. Swan, 20, Fenwick Road, East Dulwich, gentleman; H. W. Brown, 79, High Street, Beckenham, journalist. The number of directors is not to be less than three nor more than seven: the first are the first three subscribers. Qualification £1,000. W. A. Williams and W. T. Gibbs are the managing directors, with £500 each per annum, and a share in the profits. Registered by Ashurst and Co., 17, Throgmorton Avenue, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Column Printing Telegraph Syndicate, Limited (29,493).—This company's annual return has just been filed. 289 shares have been taken up out of a capital of £25,000 in £50 shares. 100 are considered as paid, and £50 per share has been called on the others. £8,940 has been paid, and £510 remains in arrears.

D. Hulett & Company, Limited (29,463).—This company's annual return was filed on September 29th, when the whole capital of £35,000 in £5 shares was taken up. 4,100 shares are considered as paid, and £9,500 has been paid on the others.

Accumulator Syndicate, Limited (52,514).—This company's statutory return has just been filed. The whole capital of £30,000, in £1 shares, has been taken up, and 25,000 are considered as paid. 10s. per share has been called on 4,993, and £1 per share on seven, and £2,503 10s. has been paid.

CITY NOTES.

West India and Panama Telegraph Company, Limited.

The forty-first ordinary general meeting of the shareholders of this company was held on Wednesday last at Winchester House, Old Broad Street, under the presidency of Mr. W. Andrews.

The Chairman said he was sorry to be occupying that position. The melancholy and sudden death of their late chairman, Mr. Earle, was a great sorrow to them all, because they had been connected with him so many years in the management of the company. Turning to the report, he said the gross receipts for the half-year had amounted to £38,209 15s. 4d., and for the corresponding half-year they were £42,317 13s. 10d., consequently there was a diminution of £3,124 9s. 1d. The expenses last half-year were £21,426 17s. 10d., as against £22,280 14s. 7d. That reduction of about £800 was only an apparent one, for it arose simply from an adjustment of the depreciation account, and the real expenses remained about the same. Their revenue would have been less than it was had it not been for the fact that the French cable was broken, which brought them in a certain amount of additional revenue. They all knew the reasons why the company enjoyed such a small business, the principal one being the wretched state of the West India Islands. They had been going from bad to worse, their business was becoming more and more restricted, and the position had at last become so bad that the Government recently appointed a Commission to inquire into the causes, and to suggest remedies. That Commission had come to certain conclusions; but, after all, what they recommended were not remedies, but only palliatives, which would take many years before they could have any good effect. To his mind the only logical recommendation was that made by one of the Commissioners, which was that as the bounties given to sugar grown abroad were the real cause of the present deplorable position of the West Indies, we should meet that state of things by putting on countervailing duties. In face of all their other troubles the company now had to meet real competition. They had been threatened for a good many years, but it was only just now that they had actually had to meet it. As the meeting was probably aware, there were two French colonies in the West India Islands, and of late years the idea seemed to have been formed in the French Government that it would be well to have an independent system of French cables to connect the islands with their own territory. That was done some years ago, and as a result they lost the subsidy of about £4,000 a year which they used to receive from the French Government. Now the British Government came in with another subsidised cable to connect Bermuda with Jamaica. The effect of that would be that there would be three competitors working for the business which hitherto had not been sufficient to decently support one company. In the face of that he was sorry to say that circumstances pointed to the probability of their having to make a rather large renewal of cable. They would have to take the money for that purpose from the reserve fund. It was a disagreeable thing to have to do, but there was no help for it, unless they wished to see their business go away from them. The policy of the board was, that they should keep their cables in good order, so that they might be able to continue to render the important services to the Government and the country which they had rendered up to the present time. If hereafter the continuance of the system should be imperilled owing to the competition of the subsidised cables to which he had referred, his opinion was that Mr. Chamberlain, or the Government, would not allow such a valuable system to go under for want of a little sup-

port. He firmly believed that if occasion arose they would find that the Government would help them. But, after all, what was really at the bottom of the whole thing was not the competition, but the miserable condition of the islands they had to serve.

Mr. Henry Holmes seconded the motion, and after some discussion the report was adopted.

The Western and Brazilian Telegraph Company, Limited.

The directors' report to be presented at the thirty-fourth ordinary general meeting of the company to-day at Winchester House says:—"The directors submit their report and the accounts of the company for the half-year ended June 30th, 1897. The total earnings amount to £59,754 17s. 8d., as against £71,082 4s. 9d., a decrease of £11,327 7s. 1d. compared with the half-year to June 30th, 1896. The loss of revenue is to a great extent owing to the very low rate of exchange prevailing during the half-year, and also to a falling off in traffic. This is partially accounted for by the fact that the cables of the River Plate Telegraph Company, Limited (between Monte Video and Buenos Ayres and with which company this company has a working agreement) were closed by order of the Argentine Government from January 30th to August 9th. The working expenses amount to £44,575 12s. 4d., as against £37,428 9s. 1d., an increase of £7,147 3s. 3d.; the greater part of which, viz., upwards of £6,000, was caused by the hire and expenses of shipping to replace the *Norseman* during repairs and on account of maintenance. Including the amount brought forward from 1896 (£6,405 11s. 5d.) the balance to the credit of the revenue account is £29,084 16s. 9d., from which has to be deducted £8,983 10s. 5d. for debenture interest, and £1,625 13s. 2d. for income tax. For the purpose of equalising dividends the directors have transferred £7,500 from the reserve fund, and now recommend the payment of a dividend, free from income tax, for the half-year at the rate of £2 per cent per annum, as against £2 per cent. per annum for the corresponding period, carrying forward £3,867 15s. 2d. This dividend will be payable as follows, viz., 3s. per share to the ordinary shares, and 3s. per share to the preferred ordinary shares. Reference was made in the report for the previous half year to the successful result of the debenture re-organisation. Since then £1,300 'A' and 'B' debentures have been exchanged, making a total of £329,800 debentures exchanged, and leaving only £9,000 'A' and 'B' unexchanged. At December 31st, 1896, the debenture redemption fund had a credit balance of £116,135 10s.; from this has been deducted the cost of the premium and expenses of the issue of the new debenture stock, and the sum required to provide for the 'A' and 'B' debentures still unexchanged, leaving a balance of £47,414 10s., which has been placed to the credit of the reserve fund, which now stands at £56,181 7s. 7d. The ninth annual drawing of the 'A' and 'B' debentures took place at the company's offices on January 18th last, in the presence of Mr. W. E. Venn, notary, when debentures amounting to £16,900 were drawn, and have since been paid off at par. There is no change in the position of affairs between the Government of Brazil and the company as to the purchase of the cables. The directors report, with profound regret, the death of their esteemed colleague, Mr. C. W. Earle. Mr. T. W. Andrews has been elected to fill the vacancy. The conversion of ordinary shares into preferred ordinary and deferred ordinary shares is suspended until further notice. The dividend warrants will be posted on the 12th inst."

Imperial Tramways Company, Limited.

An extraordinary general meeting of this company was held at Bristol last Saturday. Mr. Geo. White, who presided, said that the purpose of the meeting was to pass resolutions increasing the capital of the company. In the course of his speech he made the following statement:—"It will be observed that we have provided for the issue of debenture stock, and in connection with the general issue we shall offer the present holders of terminable debentures an exchange into stock. Now, in connection with the proposed increase of capital, I have to refer to the position and prospects of the new Middlesbrough, Stockton, and Thornaby electric tramways. I explained to you at our last meeting that this undertaking was, in our opinion, a typical electric tramway scheme, joining up and permeating three important boroughs which embrace a population of over 70,000 people. I also told you when we last met, that the moment we felt assured of obtaining the Parliamentary powers our managing director and engineer, Mr. Robinson, had at once set to work to prepare all his plans and to give out orders for rails and permanent way material. We are pushing on all the works very rapidly with the intention of opening in good time for next summer's traffic, and from the rate of progress already made by Mr. Robinson, I have no doubt we shall succeed. Since the last meeting we have been engaged in considering with our legal advisers the mode of issuing the capital, and we were also approached by an important company who were anxious to purchase our old lines with the benefit of the new Act. They offered us a cash profit on our book value of the concern, besides a substantial amount in shares in a new undertaking, but, appreciating to the full the value of our property, we preferred proceeding with our programme and obtaining the full result of our work for our own shareholders. We know we have an undertaking in hand which not only ourselves, but other experts who have studied the subject, believe is capable of yielding a good return upon the capital outlay. We have now made satisfactory purchases of all material, and our estimates of plant cost are being justified. We have laid two miles of single tramway since September 1st, and then we can closely gauge our position on this item. We have also concluded a very satisfactory cash contract with the British Thomson-Houston Company for the electrical plant and equipment of the line. I have had some experience in the cost of electrical plant, and may say that I am satisfied our contractors have cut the prices very closely. Included in the present equipment are 50 double bogie cars, each capable of carrying 60 passengers, so that we are determined to have enough carrying accommodation. I mentioned at the last meeting that our capital expenditure would be from £200,000 to £250,000, but I can now tell you that the lower sum is not likely to be exceeded. I will give you the details, so that you may follow the position exactly. The amount at which the old lines stood in the company's last capital account was about £18,000; to this there has since been added the purchase price of Stockton and costs of the Act, which, after allowing for the purchase of Darlington, carried to a separate account, and the amount to be received for old plant, brings the initial cost out at about £30,000. Our new lines will cost approximately £73,000, and our electrical construction, plant, machinery, and cars about £70,000, whilst the purchase of land for depôts, building of power station and car sheds, payments to local authorities in connection with roads, interest on outlays up to date of opening, &c., will be approximately £25,000—thus the total outlay upon this undertaking will be covered by about £200,000. You will remember we had over £20,000 cash in hand at the end of last half-year, and it is intended to raise the necessary balance in the following manner:—Debenture stock (4½ per cent.), £70,000; 6,500 preference shares (6 per cent.), £12 each, £78,000; 2,230 ordinary £6 shares, £13,380; total, £161,380. In consideration of the capital responsibilities assumed by my firm for the company, as explained at the last meeting, it has already been agreed that they shall take up at par the debenture stock and the small issue of ordinary shares. Then with regard to the preference shares, it is proposed to issue them to the ordinary shareholders in the proportion of one new preference share for every three ordinary held at the time the allotment is made. The price of issue is £12 a share, and as the existing preference shares stand at 14½-15 in the market, the value of this allotment will be equivalent to a bonus of 15s. to £1 on each ordinary share. When these issues are completed, the reserve funds will total about £45,000, and our capital will stand as follows:—4½ per cent. debentures, £100,000; 6 per cent. preference, £100,000; ordinary, £120,000; total, £320,000. In order to pay the interest on the debentures and preferences and maintain our 6 per cent. on the ordinary shares, the net revenue from our undertaking should be £17,700 a year. Taking, therefore, our annual net revenue from—London United shares, £5,600; Corris, Reading, and Darlington, £2,100; Middlesbrough, Stockton, and Thornaby (say), £10,000, we have the necessary £17,700. But I may at once point out to you that in estimating £10,000 as the profit at Middlesbrough we are only assuming a return of 5 per cent. on the total outlay, whereas on such an electrical system worked under such favourable conditions, and therefore at a minimum cost, our experience leads us to believe we shall be well within the mark in assuming 7½ per cent. return at least, or £15,000. If we obtain such a return it will mean an increased profit sufficient to lift the dividend on our Imperial ordinary shares from 6 per cent. to approximately 10 per cent., and whilst in recommending you to make these issues it is enough for me to assure you that there is no doubt whatever about the maintenance of your 6 per cent. dividend, you will see that we look forward with considerable confidence to being able to increase the dividend on our ordinary shares in a very substantial manner.

The Solicitor having explained the amendments proposed in the articles of association, the formal resolution was carried unanimously.

Crompton & Co., Limited.—An extraordinary general meeting of this company will be held at Cannon Street Hotel on Monday, November 29th, at 3 p.m., for the purpose of passing resolutions of which shareholders have been notified in official circulars, for the cancelling of the capital which has been lost, as explained to the shareholders at the recent meeting. The resolutions cover the reduction of capital by reducing the amount of the preference shares, and cancelling 2.000 ordinary shares, and the remaining ordinary and preference shares will be placed on an equal footing. There will be a special meeting of preference shareholders immediately at the close of the above for the purpose of modifying the rights of the holders of the preference shares, in accordance with the resolutions. These notices of meetings are accompanied by a further circular, explaining the proposal in detail.

A meeting of the preference shareholders will be held at Cannon Street Hotel on Monday, November 29th, at 3 30 p.m.

Direct West India Cable Company, Limited.—Letters of allotment and regret have been posted.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending November 17th, 1897, were £1,041; week ending November 8th, 1896, £1,036; increase, £5; total receipts for half-year, 1897, £17,580; corresponding period, 1896, £17,747; decrease, £173.

The Great Northern Telegraph Company. The receipts in October, 1897, were £24,400; January 1st to October 31st, 1897, £238,600; corresponding months, 1896, £237,600; corresponding months, 1895, £261,600.

The Liverpool Overhead Railway Company. The receipts for the week ending November 7th, 1897, amounted to £1,341; corresponding week last year, £1,065; increase, £276.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending Novmeber 5th, 1897, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,739.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, November 3rd.	Closing Quotation, Nov. 10th.	Business done during week ended November 10th, 1897. Highest.	Lowest
149,900£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	...	101 —105	101 105	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	5⅛ – 6⅛	5⅛ – 6⅛	...	...
923,960£	Anglo-American Teleg., Ltd. ...	Stock	£2 2s.	£2 9s.	£2 13s.	57 – 59	57 – 59	...	...
3,038,020£	Do. do. 6 % Pref.	Stock	£4 4s.	£4 18s.	£5 6s.	104 – 105	104 – 105	105	104
3,038,920£	Do. do. Defd.	Stock	...	...	...	12¼ – 12⅝	12¼ – 12⅝	12⅝	...
130,000	Brazilian Submarine Teleg., Ltd.	10	7 %	7 %	...	16 – 16⅛	16 – 16⅛	16 5/16	16⅛
75,000£	Do. do. 5 %, Debs., 2nd series, 1926 ...	100	5 %	5 %	...	114 –118	114 - 118	...	..
44,000	Chili Telep., Ltd., Nos. 1 to 44,000 ...	5	2½%	4 %	4 %	3¼ – 3⅜	3¼ – 3⅜	...	...
10,000,000$	Commercial Cable Co. ...	$100	7 %	7 %	7 %	185 – 190	185 190	187	185
653,586£	Do. Do. Sterling 500 year 4% Deb. Stock Red.	Stock	...	...	...	105 –107	105 –107	106½	105⅞
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	1½%	1½%	2 %	3/16 – 4/16	3/16 – 4/16	...	...
16,000	Cuba Teleg., Ltd. ...	10	8 %	8 %	8 %	8½ - 9½	8½ - 9½	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	18½ - 19½	18½ - 19½	...	...
12,931	Direct Spanish Teleg., Ltd. ...	5	4 %	4 %	4 %	4 — 5	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 11	10 — 11	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000	50	4½%	4½%	4½%	103 –106%	103 –106 %	...	..
60,710	Direct United States Cable, Ltd. ...	20	2 %	2½%	2½%	10¼ – 10⅜	10¼ – 10⅜	10 5/16	10 5/16
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½%	6½%	6½%	17 – 17½	17 – 17½	17¼	17
70,000	Do. 6 % Cum. Pref.	10	6 %	6	6%	18 – 19	18 – 19	18½	18½
89,900£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5%	101 –104	101 - 104	...	...
1,302,615£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4%	131 –134xd	131 - 134	132½	131½
250,000	Eastern Extension, Australasia and China Teleg., Ltd.	10	7 %	7 %	7½	18 – 18½	18 – 18½	18⅜	18⅛
35,500£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5%	100 –104	100 –104	...	...
133,100£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5%	101 –104	101 – 104	...	...
320,000£	Do. 4 % Deb. Stock ...	Stock	4 %	4 %	4%	131 –134	131 –134	134	131⅜
51,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5%	100 - 104	100 - 104	...	...
69,200£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5%	101 –104	101 - 104	101½	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4%	103 –106	103 - 106	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4%	108 –111%x	08 111 %	...	...
180,227	Globe Telegraph and Trust, Ltd. ...	10	4½%	4½%	4½%	11½ – 12	11½ – 12	11⅞	11⅝
180,042	Do. do. 6 % Pref. ...	10	6 %	6 %	6%	17 – 17½	17 – 17½	17 7/16	17⅛
150,000	Great Northern Teleg. Company of Copenhagen ...	10	8⅝%	10 %	10⅛	26½ – 27½	26 – 27	26⅝	25¼
160,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5%	102 –105	102 –105	102	
17,000	Indo-European Teleg., Ltd. ...	25	10 %	10 %	10%	53 – 56xd	53 – 56	53½	53
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs. ...	100	6 %	6 %	6%	107 –110	107 - 1 0	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000...	5	4 %	4 %	...	2 — 2½xd	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597 ...	5	5 %	5½%	5½%	6⅛ – 6⅜	6⅛ – 6⅜	6⅜	6 3/16
15,000	Do. 6 % Cum. 1st Pref. ...	10	6 %	6 %	6 %	15 — 17	15 — 17	16 1/16	15⅝
15,000	Do. 6 % Cum. 2nd Pref. ...	10	6 %	6 %	6 %	14 — 16	14 — 16	15½	14 9/16
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6 — 6½	6 — 6½	6½	...
130,766	Do. do. Nos. 119,235 to 250,000, £4 paid	5	...	...	...	3¾ — 4¼	4⅛ — 5¼	5	...
1,329,471	Do. 5½ % Deb. Stock Red. ...	stock	5½%	5½%	5½%	104 –109	104 –109	105½	104
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	4½%	5 %	5 %	9/16 – 11/16xd	9/16 – 11/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	107 - 110	107 – 110	...	...
11,839	Reuter's Ltd. ...	8	nil	5 %	5 %	7 — 8	7 — 8	...	...
3,381	Submarine Cables Trust ...	Cert.	...	...	...	136 141	36 –141	...	...
58,000	United River Plate Teleph., Ltd. ...	5	3 %	4 %	...	3⅜ - 4¼	3⅜ — 4¼	...	...
146,733£	Do. do. 5 % Debs. ...	Stock	5 %	5 %	...	102 –107	102 107	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109 ...	10	nil	4 %	nil	4¼ - 5¼	4¼ - 5¼	...	...
213,400	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	103 - 106	103 106	105½	...
64,256	Western and Brazilian Teleg., Ltd. ...	15	3 %	3 %	2 %	9¼ - 9⅜	9 – 9⅛	9 5/16	9¼
33,129	Do. do. do. 5 % Pref. Ord.	7½	5 %	5 %	5 %	7½ - 8	7½ 7⅝	7⅝	7¼
33,129	Do. do. do. Def. Ord. ...	7½	1 %	1 %	...	2¼ - 2⅜	2 — 2¼	2⅜	...
382,230	Do. do. do. 4 % Deb. Stock Red. ...	Stock	...	...	...	106 –109	06 –109	105	...
88,321	West India and Panama Teleg., Ltd. ...	10	⅛%	⅛%	1 %	⅜ — 1	⅜ - ⅞	11/16	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	9⅜ - 10¼	9¼ - 9¾	10	9¼
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	7 — 8	7 — 8	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	107 - 110	107 110	...	..
1,163,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7%	106 - 110	103 –107	109½	..
160,100	Do. do. 7 % Stor. Bonds	100	6 %	6 %	6%	100 - 105xd	100 –105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4%	5 %	6 %	12 - 13	12 — 13	12 7/16	...
20,000	Do. do. do. do. 4½ % Cum. Pref.	5	...	...	...	6 – 6½	6 — 6⅛	6 5/16	6½
26,000	Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	10 – 10½	10 – 10⅛	10⅛	10⅜
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	4½%	4½%	110 –113	110 –113		
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	5 %	5 %	7 %	25 – 26	25 - 26	25⅜	25 7/16
10,000	Do. do. Prov. Certs.	5	...	...		24 – 25	24 – 25	24⅜	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	17 - 8	17 — 18	17⅜	...
400,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	131 –136	131 –136	...	...
22,475	County of Lond. & Brush Prov. E. Ltg. Ltd., Ord. 1—22,475	10	...	nil	nil	12⅜ - 13¼	12⅜ – 13¼	12⅞	1213/16
20,000	Do. do. do. 6% Pref., 40,001– 60,000 ...	10	...	6 %	6 %	15¼ — 15⅝	15¼ — 15⅝	15⅝	15½
10,000	House-to-House Elec. Light Supply, Ord., 101 to 10,100	5	...	...	.	9 — 9½	9 — 9¼	9⅝	9¼
10,000	Do. do. 7 % Cum. Pref. ...	5	...	...	..	10⅞ – 11¼	10⅜ — 11¼	11 1/16	10 15/16
49,300	Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	3 %	4 %	5 %	17½ — 18½	17⅜ – 18½	18 7/16	7 7/8
12,500	Do. Ord., 50,001—62,500, iss. at £2 prem. ...	10	...	...	...	17 18	17 — 18	...	...
220,000	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	19 – 123	19 –123	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	1 %	2 %	4 %	15 – 16	15½ – 16¼	16¼	15⅝
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	5½%	7½%	10½%	16 – 17	16 — 17	16 5/16	16 9/16
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9½ 10½	9½ – 10½	...	...
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	103 –106	103 –106	...	...
43 341	South London Electricity Supply, Ord., £2 paid	5	...	...	...	1⅜— 2¼	1⅜— 2¼	2	...
67,900	Westminster Electric Supply Corp., Ord., 101 to 68,000	5	5 %	7 %	9 %	14½ 15½	14½ – 15½	15½	14¾

* Subject to Founder's Shares.

† Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid.

§ Dividends paid in deferred share warrants, profits being used as capital.

‖ Dividends marked ‖ are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES - *Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, Nov. 3rd.	Closing Quotation Nov. 10th.	Business done during week ended Nov. 10th, 1897. Highest.	Lowest
20,000	British Electric Traction	10	...	...	...	12⅜— 13¼	12⅜— 13¼	13¼	...
90,000	Brush Elecl. Engng. Co., Ord., 1 to 90,000...	3	2½%	...	...	1½— 1⅝	1½— 1⅝	1 3/16	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	3 %	...	...	1⅝— 2⅛	1⅝— 2⅛	...	...
125,000£	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	...	...	107 —111	107 — 111	110½	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	98 —102	98 —102	...	...
19,126	Central London Railway, Ord. Shares	10	...	...	...	9⅜— 10¼	9⅜— 10¼	10	.
143.105	Do. do. do. £6 paid	10	...	...	...	5½— 6	5½— 6	5⅝	...
58,830	Do. do. Pref. half-shares £1 pd. ...	...	...	...	...	1 — 1½	1 — 1½	...	...
61,777	Do. do. Def. do. £5 pd. ...	...	...	...	...	4 — 4½	4 — 4½	...	...
630,000£	City and South London Railway	Stock	1½%	(1 3/16)%	1 3/16%	69 — 71	69 — 71	70	69½
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	*nil*	*nil*	...	1½— 2	1½— 2	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	5 %	5 %	5½%	2¼— 2⅜	2¼— 2⅜	2 5/16	...
17,139	Do. do. do. "A" Shares 01—017,139	5	5 %	5 %	5½%	4 — 5	4 — 5	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	5 %	6 %	2 — 2½	1⅞— 2⅛	2⅛	2
16,343	Do. do. 7 % Cum. Pref., 1 to 16,343 ...	2	7 %	7 %	7 %	3⅛— 3⅜	3⅛ — 3⅜	3⅛	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	...	...	⅛— ⅜	⅛— ⅜	...	...
67,275	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	...	...	⅛— ⅜	⅛— ⅜	...	...
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	10½%	...	9 — 11	9 — 11	...	...
12,500	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	6 %	8 %	10 %	19½— 20½	19½ — 20½	20 3/8	19⅜
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	18½— 19½	18½— 19½	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	4½%	4½%	110 —115	110 — 115	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. - ...	10	10 %	10 %	10 %	21 — 22	21 — 22	21⅜	...
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	103 —107	103 —107	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	1½%	2⅜%	2⅜%	11⅜ — 11½	11½— 11⅝	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	16 — 16½	16 — 16½	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	15 %	36 — 39	36 — 39	38	37½
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	102 —105	102 —105	...	...
54,000£	Waterloo and City Railway, Nos. 1 to 54,000	10	...	...	...	12⅜— 13¼	12½— 13	13	13⅜

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked ‖ are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1895—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

* Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 7⅞, £5 (fully paid) 9½.

Electric Construction Corporation, 6 % Debentures, 104—107.

House-to-House Company, 4½% Debentures of £100, 108—110.

Kensington and Knightsbridge Electric Lighting Company, Limited Ordinary Shares £5 (fully paid) 14—14½; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½. Dividend, 1896, on Ordinary Shares 7 %.

London Electric Supply Corporation, £5 Ordinary, 2—2¼.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 8—8½. Dividend for 1896—6 %.

* From Birmingham Share List.

Bank rate of discount 3 per cent. (October 14th, 1897).

NEW PATENTS.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents, 322, High Holborn, London, W.C., to whom all inquiries should be addressed.*]

24,665. "Improvements in anodes and in the electro-deposition of nickel and other metals." H. Wiggin & Co., Limited, and G. A. Boeddicker. Dated October 25th.

24,699. "Improvements in electric bells or gongs." C. McCann. Dated October 25th.

24,715. "The improved universal electric lamp for cycles and other vehicles, military and other field work." P. H. Emanuel. Dated October 26th.

24,723. "Pneumatic electric system of communication between railway passengers and guard or other railway servants." W. G. Kidd. Dated October 26th.

24,754. "Improvements in electricity meters." G. Hookham. Dated October 26th.

24,792. "Telegraphic transmitter for ocean cables." D. Lynch. Dated October 26th.

24,829. "Improvements in coin-freed mechanism applicable to gas, electricity, and like meters." S. Simpson. Dated October 26th.

24,883. "Improvements in and relating to electricity meters." J. Routin and C. E. L. Brown. Dated October 26th.

24,854. "Improvements in electric arc lamp and other mechanisms." H. J. Spencer and W. Fennell. Dated October 27th.

24,884. "Improvements in electro-deposition apparatus." A. F. Harris. Dated October 25th.

24,913. "Improvements in connection with electric traction systems." H. J. Spencer. Dated October 27th.

24,925. "Improvements in primary batteries." E. Giglio. Dated October 27th.

24,950. "Improvements in circuit arrangements for wireless telegraphy." A. C. Brown. Dated October 28th.

24,958. "Improvements in electric tramway and electric transmission of power system." C. W. G. Little. Dated October 28th.

25,061. "Improvements in switches for motors." H. H. Turner, A. Turner, A. Turner, and G. Shaw Aveyard. Dated October 29th.

25,076. "Improvements in, and connected with, the electric propulsion of barges and boats on canals and rivers." H. W. Handcock and A. H. Dykes. Dated October 29th.

25,141. "A decorative reflector for incandescent electric lamps." F. Deimel, J. Lehmann and A. Sylten. Dated October 29th.

25,183. "Improvements in, and relating to, brackets, chandeliers, electroliers, and the like." C. Darrah and T. Gibson. Dated October 30th.

25,205. "Improvements in coin-freed electric shock machines." G. Poore. Dated October 30th. (*Complete.*)

25,210. "Improvements in the method of, and means for, transmitting electric currents in tramways." Max Rosher. Dated October 30th. (*Complete.*)

25,212. "Improvements in grapples for submarine cables." J. Imbay. (La Société Industrielle des Telephones, France.) Dated October 30th.

25,235. "A roller-bearing locking or under carriage, applicable especially to electrical and other motor vehicles." The Hon. R. T. D. Brougham. Dated October 30th.

24,950. "Improvements in circuit arrangements for wireless telegraphy." A. C. Brown. Dated October 28th.

25,243. "Improvements in controlling the supply of electric energy and in apparatus therefor, applicable more especially for varying the power or brilliancy of electric lamps." N. Staniland and O. P. Macfarlane. Dated October 30th.

25,244. "An improved arc lamp." P. Mersch. Dated October 30th. (Date applied for under Patents, &c., Act, 1883, Section 103, October 11th, 1897, being date of application in France.)

25,245. "An improved method of varying the speed of electric motors, or the electromotive force of dynamo electric machines." H. H. Lake. (Eugenio Cantono, Italy.) Dated October 30th.

25,246. "A process for the electrolytic separation of metals." H. Von der Linde. Dated October 30th.